SCIENTIFIC AMERICAN SUPPLEMENT. № 1677

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York

Scientific American, established 1845.
Scientific American Supplement, Vol. LXV., No. 1677.

NEW YORK, FEBRUARY 22, 1908.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE SAND SEAS OF WESTERN UNITED STATES WHICH OVERWHELM HOUSES AND RAILROADS.

Illustrated London News.

SAND WAVES AND DUNES OF THE SAHARA DESERT.

SAND WAVES AND THEIR WORK.—[SEE PAGE 120.]

GUMS, RESINS, AND THEIR PROPERTIES

A FEW TECHNICAL SUGGESTIONS.

ROSIN is the cheapest and commonest resin (the term resin is used to designate *all* substances of this nature), and is obtained in the distillation of turpentine oil from crude turpentine. Three grades of rosin are known to commerce: Virgin, yellow dip, and hard. The first turpentine that exudes from the tree after it has been boxed, is "virgin rosin." It has a light amber color. Yellow dip is the next best grade, and the hard is really the scrapings from the tree after the turpentine refuses to run. It is very dark colored. White rosin contains water which renders it opaque. If the water is driven off, the rosin becomes yellow.

The chief uses of rosin are in the manufacture of cheap varnishes, soaps, in the lining of beer kegs and casks to make waterproof, as a flux in soldering tin, and in various mixtures of greases, belt dressings, and adulteration of oils.

When rosin is distilled, "rosin oil" is produced. This is used in the manufacture of printing inks. It is also used to adulterate linseed oil. The hard rosin that is dark colored is frequently called "turpentine pitch." Rosin is soluble in turpentine and benzine, but only slightly in alcohol.

Wood-tar pitch is obtained in the distillation of wood for making wood alcohol and acetic acid. It should not be confused with turpentine pitch as it has more the nature of a coal tar, while turpentine pitch is rosin.

Burgundy pitch closely resembles common rosin. It is obtained from the Norway spruce and is lighter in color. It has the peculiar property of combining into a solid mass within a short time after it has been broken up. Although quite brittle, it is plastic, particularly in summer, and it is impossible to preserve it for over a few hours in the pulverized condition. It soon melts, so to speak, into a solid mass.

Gum sandarac is called "gum jupiter," and is obtained from a tree growing in the northern part of Africa. Its principal use is in the manufacture of varnishes.

Gum mastic resembles gum sandarac in appearance and its properties, and is obtained from shrubs which grow along the shores of the Mediterranean Sea. Both gum mastic and gum sandarac are soluble in acetone, turpentine, and alcohol. Gum mastic is used in varnish making.

Gum dammar is found in the Moluccas and exudes from a tree similar to the pine. It is a very light colored gum, and is used for the manufacture of the lightest colored or transparent varnishes.

Amber is not a true gum, as it is not produced by any tree or plant at the present time. It is a "fossil resin," as it was formed in primeval times, probably in the same manner that other gums are now produced. Germany produces nearly all of the amber, and it is cast up on the shores of the Baltic in storms. The fact that it frequently contains insects indicates that it was of vegetable origin. The insects became entangled in the gum as they are to-day in those which are now found. Amber is very hard and takes a high polish. It is not soluble in any of the solvents. When heated above its melting point, however, it is partially decomposed and then may be dissolved by turpentine or alcohol. When amber is distilled, oil of amber is produced. If this oil is treated with nitric acid, an artificial musk is produced. A fine varnish is made from amber.

Kauri gum is also called Australian dammar. It is obtained in New Zealand and is the fossil remains of some kind, as it is dug from the earth. Insects are found in this gum as they are in amber. Kauri gum is darker in color than the true gum dammar.

Gum copal, with the exception of amber, is the hardest gum. It also has a light color and is used in the manufacture of the best grades of varnish. In order to dissolve it, however, it must first be melted and turpentine and oil added to it. This fact accounts for the frequent clouds of smoke that exude from the chimney of a varnish factory. The turpentine and oil often catch fire under these circumstances.

The hardest copal is a fossil gum and is found in tropical countries, buried in the earth like amber and kauri gum.

Dragon's blood is a red colored gum that is obtained from the fruit of a palm tree found in the East Indies. It exudes from the fruit and is collected by the natives, melted and cast into sticks which are rolled in the hands to make into long rods. These rods are wrapped in fiber and thus are found in the market. It is soluble in alcohol, and is now and then used in the manufacture of colored varnishes. Its principal use is in etching and photo-engraving. It is employed for dusting on the plate to be etched when a design has been transferred to the metal. The dragon's blood adheres to the varnish and increases its thickness and consequent ability to resist the solution used for etching. Asphalt is used for the same purpose, but the dragon's blood is preferable, as it melts at a lower temperature.

Gum guaiacum is obtained from a tree which grows in the West Indies. The tree is cut in the same manner that a pine tree is treated for obtaining turpentine and the gum exudes. This gum is not extensively used. It is employed to a limited extent in medicine for the treatment of rheumatism. It is also used in the etching of steel knives. Gum guaiacum is soluble in alcohol, and a varnish is produced. This is brushed over the knife and allowed to dry. A rubber stamp is stamped upon a pad of cotton cloth wet with a solution of potash and then upon the surface of the steel knife coated with the varnish. The rubber stamp has the design that is to be etched upon the steel. The potash dissolves the gum and leaves the steel bare. The etching is then done with nitric acid diluted with four parts of water. The gum guaiacum is quite soluble in alkalies, which makes this etching process possible.

Gum shellac is produced by the bite of insects upon the branches of certain East Indian trees. The shellac exudes in the form of drops which cover the insects. These drops are collected and melted in muslin bags by means of hot water and the insects strained out. The melted shellac is poured onto a hot plate, and the scales as they occur in commerce are produced. It is usually of a brownish-orange color.

The bleached shellac is formed by passing chlorine gas into a solution of shellac dissolved in borax. The shellac is precipitated and then melted and pulled under water in the same manner that candy is treated. This renders it white and fibrous and removes the borax.

Shellac is soluble in alcohol, and forms a hard, quick-drying varnish, extensively used for patterns, varnishing and similar work. It is also used in the French polishing of wood. The wood is given a large number of coats of thin shellac varnish, and each coat is polished or rubbed down before the other is applied. In this manner the last coat is very smooth, although not highly polished like some other forms of varnish.

Shellac is soluble in borax, and this solution may be used as a varnish or lacquer. At one time it was extensively used as a cheap lacquer, but at the present time it has been entirely replaced by the gun-cotton lacquers. Lacquer made by dissolving shellac in alcohol is now used to a limited extent, and is gradually being replaced by the gun-cotton lacquers. At one time it was the only lacquer used. It must be applied while the work is warm, in order to prevent the absorption of moisture by the alcohol and the production of a turbidity on the surface.

Gum elemi is obtained from a tree growing in the Philippine Islands. It has a white or gray color, and is soft and tough. It is soluble in alcohol. It is used in the manufacture of varnishes to toughen them when hard gums are used.

Gutta percha is the gum obtained from an East Indian tree. The crude product is purified by grinding in hot water, when all the dirt and foreign matter are removed. The mass is then formed into balls. Gutta percha is soluble in bisulphide of carbon, chloroform, and benzol. It is used for taking impressions of objects, as it becomes plastic when heated to about 140 deg. Fah. Upon cooling, it again becomes a solid. It is also used in the manufacture of a large number of tire cements, tapes, and in the making of insulated wire.

Asphalt is one of the most valuable resins. It is supposed to be the oxidized residue obtained in nature by the evaporation of petroleum. The crude asphalt contains two substances: petrolene and asphaltene. Petrolene is soluble in naphtha, benzine, or gasoline, while the asphaltene is not. The asphaltene, however, is dissolved by benzol.

The island of Trinidad supplies large quantities of asphalt, where the "pitch lake" is situated. Other countries also furnish it.

The purest asphalt is found in Utah, and is called "gilsonite." This variety is extensively used in the manufacture of asphalt varnish. It is also used in the manufacture of the so-called "hard-rubber" electrical goods.

Asphalt is extensively used in the manufacture of pavements. The Trinidad asphalt occurs in two forms: "lake pitch" and "land pitch." The latter is the harder of the two and melts at a higher temperature. Asphalt may be toughened by mixing it with heavy paraffine oil while melted.

Asphalt is soluble in bisulphide of carbon, turpentine, acetone, and benzol, but not in benzine, gasoline or naphtha. Asphalt is the best material for lining plating tanks or as a stopping-off varnish.—The Brass World.

THE PREPARATION OF GOLD TRICHLORIDE FOR PHOTOGRAPHIC PURPOSES.

By RANDOLPH BOLLING.

THE double chloride of gold and sodium and aqueous solutions of gold trichloride find extensive application in photography in connection with the toning of silver prints, in order to reduce the harsh tints to a more pleasing color. With silver paper giving a visible image, the fixing bath alone gives a picture of an unattractive brick-red or salmon color; but an alkaline solution of gold chloride, applied to the print before fixing, will be reduced by the silver of the image and the gold will be deposited upon it, changing its color to a purple or a pleasing bluish black. The most economical method of obtaining gold salts is to prepare them from the metal itself. Pure gold is worth $20.67 an ounce. It can be easily produced by solution of some alloy of gold and copper in nitro-hydrochloric acid and the application to this solution of gold and copper of some chemical reagent that will cause a precipitation of metallic gold. To begin operations, all the old scrap jewelry that can be collected, such as settings, wire, pins, old watch cases, etc., which may run from 9 to 18 karats (that is, 24 parts of the alloy contain 9 to 18 karats of gold) are broken up into small bits and placed in a pint beaker. About two ounces of scrap is a convenient weight to operate on. This is covered with a mixture of one ounce of strong hydrochloric acid and three ounces of strong nitric acid, and the acids allowed to act over night on the scrap in a warm place. Solution of the alloy takes place without difficulty, and the beaker and its contents are now allowed to stand on a water bath or hot plate heated to about boiling point and then evaporated to a thick syrup, very nearly to dryness. To the contents of the beaker containing chlorides of gold and copper is added hot water, diluting to about four ounces. Now dissolve about three ounces of ferrous sulphate (copperas crystals) in sufficient water to make a saturated solution, and add this to the contents of the beaker containing the gold and copper solution. Metallic gold, having its characteristic lustrous appearance, is precipitated, a ferric salt remaining in solution. Copper remains in solution. A funnel is now fitted with a filter paper, and the precipitated gold collected on it, and washed with hot water until it is entirely free of copper and iron salts. The precipitated gold, which has been retained on the filter, is now removed by taking the filter paper out of the funnel and placing the precipitate in another pint beaker, adding nitric and hydrochloric acids, as directed in the first treatment, and thus dissolving the gold again, evaporating to syrup or to such a degree of concentration that no odor of acid fumes is noticeable. The gold trichloride is next dissolved in water, and is now ready for "toning" baths. It is chemically pure, and is entirely free from copper salts. The final reaction is expressed thus: $Au_2 + 2HNO_3 + 6HCl = 2AuCl_3 + 2NO + 4H_2O$. A compound of gold and sodium chlorides, in molecular proportions, crystallizes readily and is more stable. This is the double chloride of gold and sodium of the photographic dealers, and can be prepared by evaporating the solution of gold trichloride to dryness as directed, weighing the residue, and adding an equal weight of sodium chloride (common salt), then adding sufficient water to dissolve both salts, and slowly evaporating to dryness again. This salt is a deep yellow color, and keeps very well. It is also of use in preparing certain toning solutions calling for a definite weight of the salt. To tone prints with the trichloride solution, add bicarbonate of soda to the gold solution until it is alkaline to litmus paper, and then immerse the silver prints in this solution until they acquire the requisite shade. The bath may be used until completely exhausted.

Balloon chases by automobiles are becoming popular in Europe. In a recent chase of this kind, M. Pierre Garnier, in the balloon "Eole III.," went up with the object of alighting after having traveled 25 miles. Automobiles followed as best they could, four prizes being offered for the first four arrivals. The aeronaut did everything possible to render the chase difficult for automobiles, simulating descent, maneuvering with the guide rope and then rising again to an altitude of a mile. Several of the pursuers contrived to be in "at the death."

THE COAL-TAR INDUSTRY.

SERVICES RENDERED BY CHEMISTS IN ITS DEVELOPMENT.

BY H. A. METZ.

In giving an account of the services of the chemist in the industry, or better, industries originating in the utilization of the various products contained in the substance known as coal tar, it is necessary to give a complete history of these industries. It is impossible to separate in any way the scientific and the commercial development, as they are so closely interwoven in the advance made in the manufacture of the various products, whether coloring matters, medicines, technical products, or raw materials. The whole displays a system of evolution which we can appreciate more thoroughly than those in some other branches of science, as we have before us the visible results of each step forward in working out the possibilities of the application of trained scientific knowledge to the problem of these industries.

Although in the first half of the nineteenth century several investigators in the examination of certain substances obtained in various ways, discovered aniline and nitrobenzene, and the fact that these substances yielded colored bodies under suitable conditions was known, it was not until 1856 that the first of what are now commonly known as "aniline dyes" was discovered and manufactured commercially.

Two years after the appearance of Perkin's mauve on the market, Hofmann discovered magenta, or fuchsine, and the next year Verguin manufactured it commercially. Medlock and Nicholson next introduced the arsenious acid process for its manufacture in 1860. In the same year Girard and Di Laire discovered that by phenylating rosaniline or magenta, a blue coloring matter was obtained, known as spirit blue, being only soluble in alcohol, and in 1862 Nicholson discovered that this spirit blue by the action of sulphuric acid would be sulphonated and made soluble in water. This introduced a new series of colors, known as soluble blue, water blues, and alkali blues.

These dyestuffs all belong to the triphenylmethane group of colors, but in 1858, P. Griess discovered what is known as the diazo reaction which opened the way to what now is the largest and most useful group of colors in practical use known as "azo colors." The first of these was introduced by Simpson, Maule and Nicholson in 1863, and called "aniline yellow." This was amido-azo-benzene, and the same firm introduced this same year the methylated and ethylated rosanilines discovered by Hofmann the year before.

In 1863 Lightfoot, in England, discovered the method of forming on the vegetable fibers what is known as "aniline black." This, although one of the most widely-known coloring matters, has defied analysis until last year, when R. Willstaeter and C. Moore claimed to have discovered the constitution of this elusive body.

The dyestuff industry at this time was located principally in England, as the names of the new colors which appeared from time to time show, but owing to the advance of technical education in France and later in Germany, it soon passed to these countries.

In 1868 Graebe and Liebermann announced an invention that had a most marked effect on commerce. This was the synthesis of alizarine from the anthracene in coal tar. The original source of this was madder root, the product of almost all warm climates, and up to that time the most important of the natural red dyestuffs. The synthetic production of the pure coloring matter reduced this trade to practically nothing and limited the profitable production to two or three countries, so that "madder-root" became largely a matter of name.

The synthesis of alizarine from anthracene led not only to immediate results in regard to the red dyestuff, but started researches for other possibilities in the production of dyestuffs from anthracene.

The effects of these efforts have been most marked. After the reds appeared orange, blue, brown, directly derived from anthracene and alizarine. Then somewhat later R. E. Schmidt brought out the higher oxyanthraquinon products which had marked advantages over the older dyestuffs. Next appeared the dyestuffs formed by the condensation of various amido bodies with anthraquinon and its derivatives, and the latest, within two or three years, vat dyeing anthracene dyestuffs. All of these are the result of patient, untiring work on the part of chemists in the employ of the several large German manufacturing establishments.

The first of the aniline colors it was found required in dyeing cotton a mordant of some kind; either the fiber had to be treated with tannin or alum, or other metallic salt had to be used in the dye bath. This condition continued until 1884, when Boettiger patented Congo red, which dyed unmordanted cotton in a bath containing merely common salt. This was followed by others in rapid succession, and to-day these dyestuffs, often called the "tetrazo dyestuffs," are one of the largest groups of coloring matters known. To this class belong the colors which are developed on the fiber, the first being the primuline yellow introduced in 1887. This is the original of all the dyestuffs which are dyed and afterward developed on the fiber, a class in general use on account of the fastness of the resulting shades.

In 1873, Croissant and Bretonnier introduced a dyestuff which they obtained by heating organic substances, such as bran, sawdust, etc., with sodium sulphide, known commercially as "Cachou de Laval." This was used in dyeing on a limited scale, but the method of making attracted little research until 1890, when Turners in England, and 1893, when Raymond Vidal in France, brought out the first of what are known as sulphide or sulphur blacks. This opened up a new field, which was immediately entered by numerous investigators, and the results are shown in the sample cards of the various manufacturers.

The greatest recent development as a result of chemical research is the manufacture and sale of synthetic indigo. The original processes for the synthesis of indigotin from toluene were discovered by Dr. A. Baeyer, in 1880, but were not commercially profitable. The Farbwerke Hoechst and the Badische Anilin und Soda Fabrik had an agreement to work out the Baeyer processes, and took up the investigation of a new process invented by Carl Heumann in 1890, using benzene and naphthaline as starting points.

Before the technical development of Heumann's method had been brought to a successful result, the Farbwerke Hoechst succeeded in perfecting a method for the commercial application of Baeyer's ortho-nitrobenzaldehyde process, and commenced the commercial manufacture of synthetic indigo by this process in 1896, and shortly afterward the Badische Anilin und Soda Fabrik, the manufacture of indigo by Heumann's process. The Société Chimique des Usines du Rhone, in Lyons, France, having at the same time succeeded in producing ortho-nitro-benzaldehyde cheaply, began also to produce indigo on a commercial scale.

While the commercial manufacture of indigo was now fully established, the most promising method, that of its production from benzene as indicated by Heumann, was still impracticable, on account of the unsatisfactory yields. A German chemist, J. Pfluger, discovered that the addition of sodium amide increased the yield sufficiently to make this process of Heumann's the most satisfactory and successful method for the synthetic production of indigo, and it is this process that is now generally used.

The cost of production of indigotin, or indigo, as it is commonly known, has decreased so rapidly that the natural indigo trade has suffered a severe decline, and the government of India has called into service a number of expert scientists for the purpose of investigating the present state of the industry and the possibility of improving the conditions caused by the competition of the synthetic product with the natural.

The synthetic product is now almost exclusively used by the large manufacturing [illegible] of the world, the total consumption in the [illegible] for the year being equivalent to 1,500,000 pounds of 100 per cent indigotin.

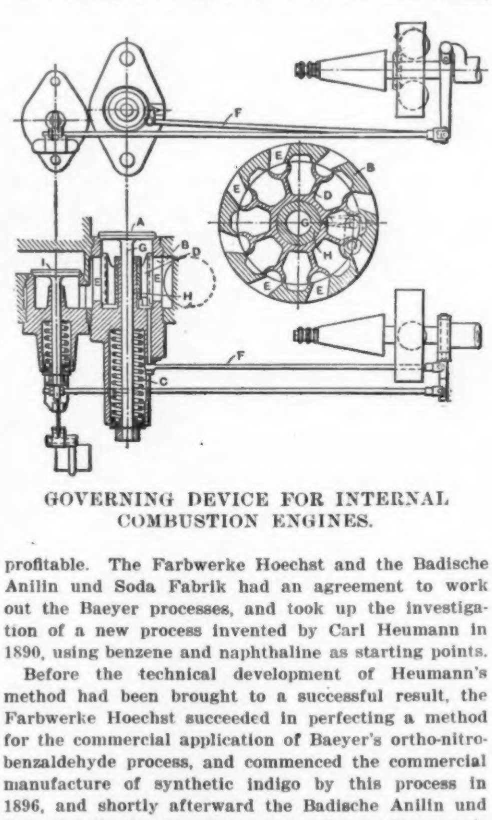
While the manufacturers were developing the coal tar dyestuff in the way shown, they were not idle in other lines, as the list of medicinal chemicals derived from coal tar shows. Some of the older ones, as antipyrine, acetanilide, and phenacetine, have become so popular as to claim even the attention of the United States government, but these are only a few of the total number.

All this is undoubtedly due to the effect of the services rendered by the chemist, as the number of products and the improvement so constantly and consistently shown in their manufacture indicate a corresponding increase in the scientific and practical knowledge of the subject.

That this is recognized by the manufacturers is shown by the number of chemists employed, some of the larger works in Germany each having 200 or more on their staff.

The manufacturing establishments in the United States have begun to employ chemists more and more in their works, and we are here to-night, to present this medal which is given as a reward of their labors in this field. If this spirit is encouraged and the use of scientific knowledge increased, the manufacturing interest of the United States will at last take its proper position among the other nations of the world.

GOVERNING DEVICE FOR INTERNAL COMBUSTION ENGINES.



GOVERNING DEVICE FOR INTERNAL COMBUSTION ENGINES.

Internal combustion engines are commonly governed by throttling the admission of gas and air into the cylinder in such a manner that when working at full load the working fluid is admitted freely into the cylinder, and practically a cylinder full is drawn in to form each working charge. As the load decreases the throttling of the admission causes a less quantity to be drawn in, and less than a cylinder full forms the charge for the next impulse of a reduced power, the degree of the throttling and the quantity drawn in to form a charge being varied by the governor.

An arrangement for obtaining the desired amount of throttling is shown in the accompanying cut. The admission valve, *A*, is arranged in a casing, *B*, and is operated by a cam and lever, moved inward by means of the lever, and returned to its seat by means of a spring *C*, the opening of the valve, *A*, taking place during each suction stroke. The inner portion of the casing, *B*, is arranged with a number of parallel slots, *E*, through which the working fluid is drawn before passing through the valve, *A*, into the cylinder. A light rotary valve, *D*, is provided, having as many arms as there are slots, *E*, the outer edges of these arms being spread out so that in one position the slots are entirely covered. When in this position, although the admission valve may open in the ordinary manner, only as much of the working fluid can gain admission to the cylinder as will be allowed by leakage past the edges of the outer portions of the rotary valve *D*. The valve *D* will be moved into this position by the governor only when there is a light load on the engine. Should the load increase, the governor, by means of the rod, *F*, rotates the valve, *D*, and opens the ports, *E*, to any desired extent. The outer end of the arms of the rotary valve, *D*, are hollowed so as to present only small fitting edges, thus reducing friction and risk of sticking. The ports, *E*, also have narrow fitting edges for the same reason. As it is not desirable to carry this method of governing down to very light loads, it is worked in combination with the ordinary hit-and-miss governing which comes into operation whenever the engine runs on very light loads, as indicated in the cut. It is not necessary therefore that the rotary valve *D* should do more than throttle the working fluid to a moderate extent, and it may therefore be left free in its movement, thus allowing the governor to move it with ease. The rotary valve, *D*, may either rotate upon the spindle, *G*, of the admission valve, *A*, or upon a sleeve, *H*, through which the spindle of the admission valve moves, this latter arrangement being shown in the cut. The governor may be arranged so as to operate the hit-and-miss governing as well as the partial rotation of the valve, *D*, as is also shown.—Mechanical Engineer.

Green Stain for Ivory.—(*a*) Solution of 1 part of picric acid in 10 parts of water; finish coloring with indigo-carmine solution. (*b*) 10 parts of aniline green in 300 parts of alcohol, filtered.

STEEL MAKING BY ELECTRICITY.

A REVIEW OF MODERN PROCESSES.

The idea of making steel by electricity is not so very new, as in 1875 William Siemens made more or less successful experiments with the electric current to produce iron from ore direct. He obtained patents in England therefor, but abandoned the idea. English experiments by others about this time were not successful. Stassano, however, in Italy, succeeded in making good steel and also good iron by an electrolytic process. It is said that he was about to leave off his experiments, but by accident moved the wrong lever, causing a strong counter-current to pass through the mass of ore, having the desired effect which he had not obtained at first. His furnace was built like an ordinary blast furnace, with this difference, that the melted metal was drawn off as soon as liquid, which was a great saving of heating medium.

Stassano mixed his material with 12 per cent of pitch and made it into briquettes; the power consumption is said to have been 2,500 horse-power hours per ton of pure iron. This low consumption may have been due in part to the great purity of the Italian ore. There are no works employing the Stassano process.

Harnet, Kjellin, Cowley, and Benedict have also made more or less successful attempts in the line of making pure iron and steel by electrolytic process.

Siemens said in the 70's: "There will come a century in which the metals will be made only by electricity, and they will be better and more perfect than ever before."

To treat the subject by classification rather than historically: Among the various processes which have been suggested for steel making by electricity, and some of which have never reached even the experimental stage, may be mentioned:

1. Those by which the crucible or other vessel containing the material to be converted is heated from without by an electric current.

2. Those intended to utilize the "Joule effect"; that is, those in which the resistance of the ferruginous material worked upon is the direct cause of the heat developed.

3. Those making use of the thermic effect of electric currents induced in the material being converted.

4. Those employing the heat of an electric arc.

Th[illegible]se processes differs from others in [illegible] made in crucibles only that instead of coke, gas, or other fuel, electricity is used as a source of externally-applied heat, with perhaps the advantage of avoiding the passage of the combustion gases through the crucible. The Girod process comes under this head.

The best known process of the second class is that of Gin, who employs a car on which is built a masonry furnace, having serpentine channels *A*, Fig. 1, connected with electric pole-pieces *B*. These channels are filled through hoppers *H* with the material to be converted.

A furnace for a modification of the process is seen in Fig. 2, in which there are two hearths, *A* and *B*, inclined in opposite directions and connected at both ends by channels *C*, each running from the deepest part of one hearth to the highest part of the other.

In the third or "induction" class come among others the furnaces proposed by Ferranti long ago, and by Kjellin more recently. In the former the magnets which introduce the electric currents lie above or below the furnace; in the latter they lie in an inner cylindrical opening, as shown in Fig. 3, in which *A* is the annular hearth, *C* an iron core passing through the central hole and surrounded by the primary coil *D*. *B* is the cover for the hearth *A*. The material is tapped off through a channel, which lies so high that half of the melted material always remains behind to keep up the continuity of the secondary current. Such a plant, installed in Gysinge, Sweden, has produced good steel from good raw materials (pig iron

Fig. 2.—MODIFIED GIN FURNACE.

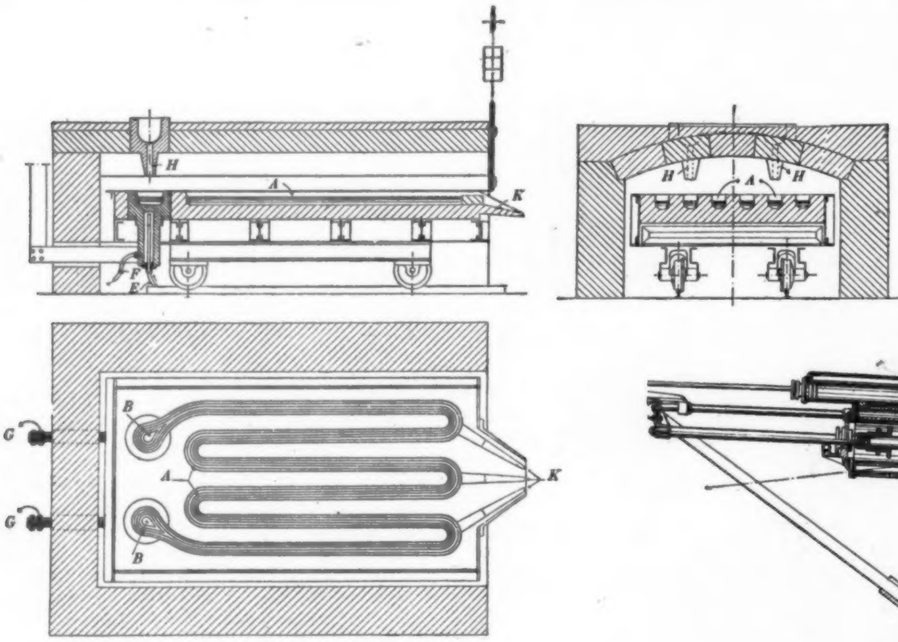


Fig. 1.—GIN'S ELECTRIC FURNACE.

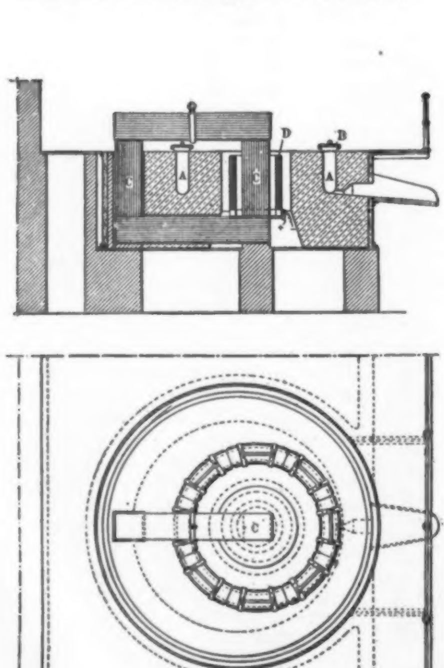


Fig. 3.—KJELLIN'S ELECTRIC FURNACE.

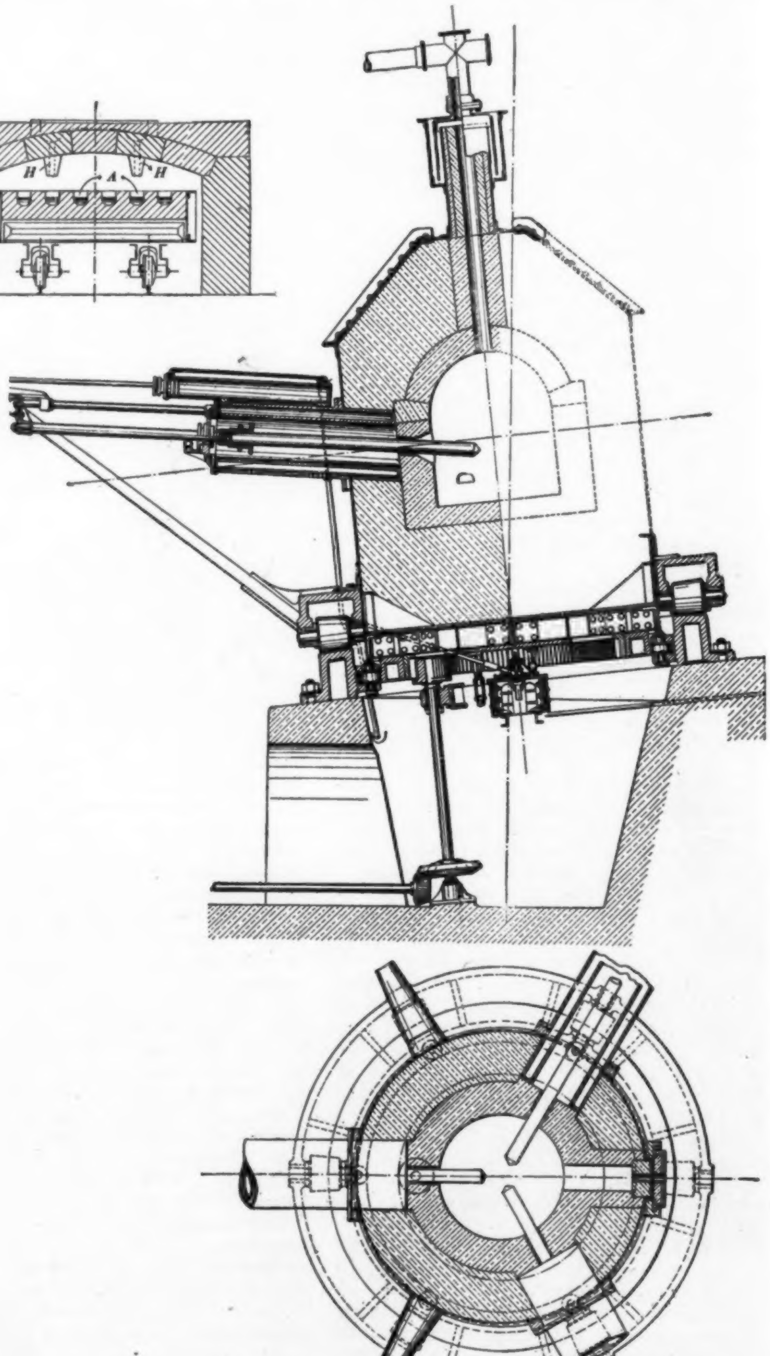


Fig. 4.—STASSANO'S ELECTRIC FURNACE.

and scrap) to which ferromanganese, ferrosilicon, etc., are added. Where good materials are at hand cheap, this furnace can give good results, as the combustion gases cannot touch the charge; but it calls for some method of deoxidation of the iron oxide in the slag; and when it comes to taking out phosphorus, there may be trouble by reason of the oxidizing action of the slag. The purification, especially from sulphur, is however made more difficult by the fact that the slag is less hot than the melted metal under it. The electric duty is higher than where an arc is used, but displacements of phase and loss by radiation more than make up for this; and there is always the great disadvantage of having to leave part of the charge in the furnace to keep the electric circuit closed, which would affect the composition of the material where spiegeleisen, etc., are used and it is intended to make a different kind of steel at each charge. When it comes to melting, only, this style of furnace has many desirable qualities.

In some induction crucibles the steel is melted by induction currents caused by a primary alternating current. The apparatus is a sort of transformer with three parallel strips of lamellated iron connected above and below with a yoke of some material. This closed magnetic circuit forms with the alternating-current coil surrounding the central strap the first part of the transformer, while the steel to be melted, contained in a ring-shaped graphite crucible surrounding the central pole, may be considered as the secondary part. In order that the heating current may from the very beginning be set up in the steel, the charge must be in the form of a closed ring in the crucible. To start, some melted steel is poured in the crucible; the rest may be added through the cover, which is in sections.

To protect the magnetic pole, which is surrounded by the coil, from the radiated heat, it is provided with a coaling jacket with circulation water, keeping the

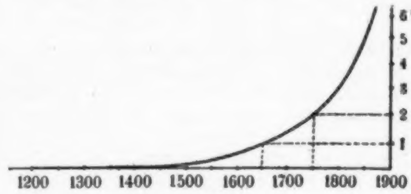


Fig. 5.—SOLUBILITY CURVE OF IRON PROTOXIDE.

temperature at about 1,700 deg. C. in the crucible from the primary coil. Melting a charge of 75 kilogrammes takes about twenty minutes; in another forty minutes the steel is ready for pouring. With unbroken work and charges of 75 kilogrammes, the current consumption is about 640 kilowatt hours per ton of steel produced.

Induction furnaces are being tried in the Schneider works (Creusot, France) and the Disston works, Philadelphia.

Of electric furnaces there are two principal kinds:

1. That in which steel is produced directly from the ore.

2. That in which it is made from pig iron, scrap, etc.

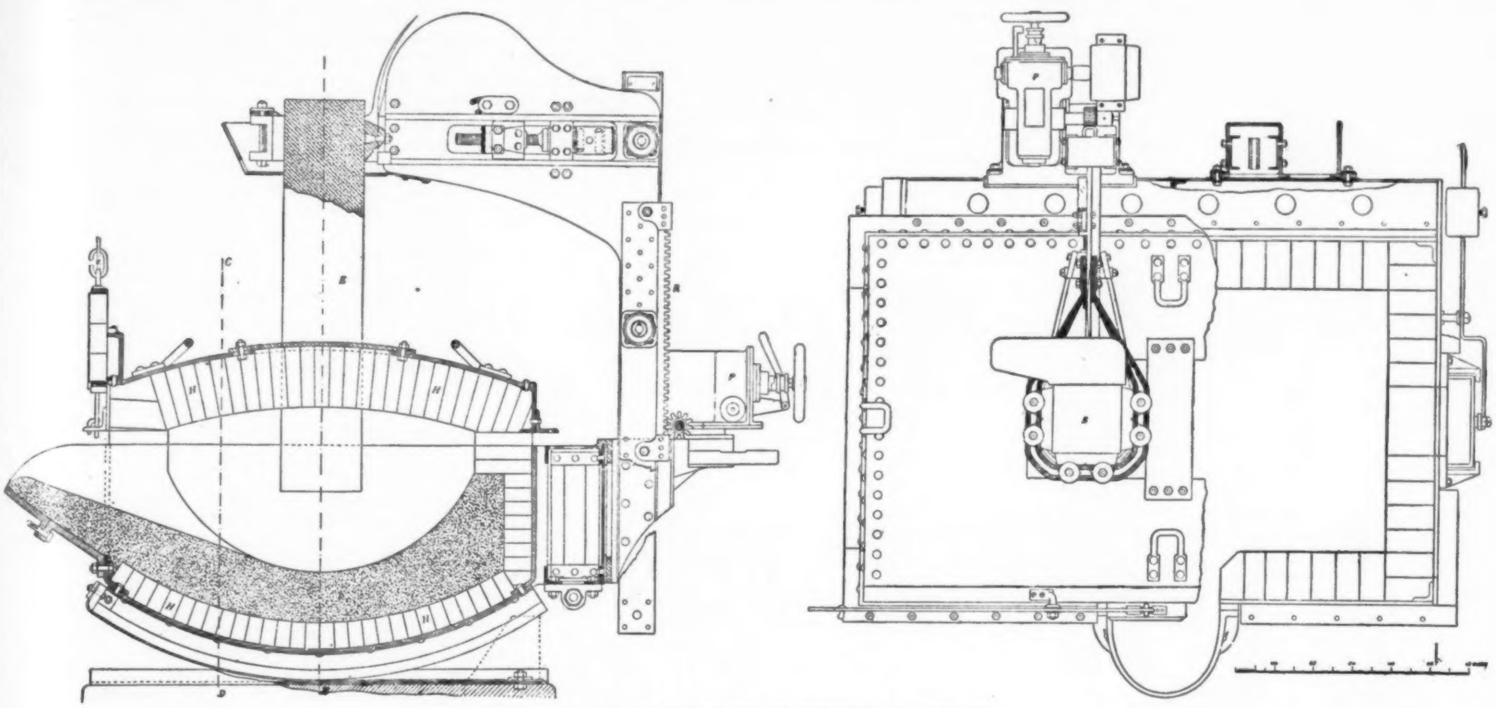
To the first class belongs Stassano's (mentioned above) in which the ore is pulverized and made up with charcoal and other necessary substances into briquettes, which are melted in a rotating furnace (Fig. 4) consisting of a cylindrical case lined with firebrick, and rotating on anti-friction rollers about an inclined axis. The current is passed through the lower channel by contact rings; in the furnace itself are three electrodes, the position of which therein is regulated by cylinders. The gases are led off above. This process is in operation in the government shops in Turin for melting shop scrap, which of itself offers no such difficulties as would be presented by the manufacture of steel.

In the Héroult process the furnace reminds one of the Martin tipping type, without heads and chambers. The current is taken by electrodes passing through the vault (Fig. 6) and any kind of material can be employed. The furnace is attacked neither by the metal nor by the slag, as is the ordinary Martin type.

The electric furnace will come into play for steel making with advantage in one of the following three directions:

1. Cheapening the manufacture.
2. Improving the quality of the product.
3. Employing ores which would otherwise not be available.

As far as cheapening the production of pig iron, this is not to be expected, in comparison with the ordinary blast furnace, if the electricity is to be generated by a steam engine and dynamo; and even where water power is very cheap there are many difficulties in the way. In Canada it could possibly be a rival of the blast furnace in this particular, and experiments have been made there with ore containing sulphur and titanium; the former being reduced to a few thousandths



Figs. 6 and 7.—HÉROULT'S ELECTRIC FURNACE.

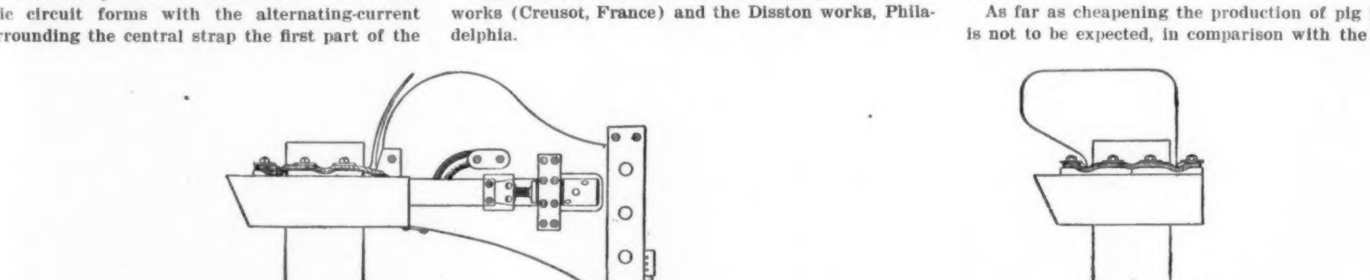


Fig. 8—HÉROULT'S ELECTRIC FURNACE.

of a per cent, and the fuel used being sawdust and other waste products. Per ton of pig the current consumption was 1,500 to 1,800 kilowatt hours.

One of the great difficulties in connection with this process is the manufacture of carbon electrodes that are large enough—say five meters long and 950 millimeters in diameter.

There is, according to Prof. F. Richard Eichhoff, in Charlottenburg, Germany (from whose interesting paper in Stahl und Eisen the illustrations and many of the facts in this article are taken), a probability of the introduction of this process in Canada, Brazil, the East Indian Archipelago, and New Zealand.

For the manufacture of such material as ingot iron (*Flusseisen*), steel for beams, etc., there is as yet no chance for the new process. With fifty-five charges the power necessary is 890 to 752 kilowatt hours. If the raw material were first made by the ordinary Martin or Thomas process, and then put in a melted state into the electric furnace merely to be purified, there would be required therein only 200 to 300 kilowatt hours. Nearly half of the power is lost by radiation in a furnace of the ordinary size. But an electric furnace for 10 tons would reduce this figure materially and enable the work to be done with 163 kilowatt hours per ton of steel produced; and for steel that does not require very much purification, it could be reduced to 130 kilowatt hours.

The great advantage of the Héroult process is that a higher one. If we imagine two masses of ingot iron (*Flusseisen*) one of which contains 0.1 per cent of carbon and the other 0.3 per cent, it is not easily seen why even when 0.1 per cent carbon was not enough to reduce all the dissolved iron oxide, 0.3 per cent or 0.5 per cent of carbon would not reduce all the iron oxide. It is even less incomprehensible because carbon has so great a resemblance to oxygen, and one which increases with the temperature. But meltings in the electric furnace have shown that even steels rich in carbon, when they contain no manganese and no silicon, can take up large quantities of iron oxide, which increase with the temperature, as shown by the unquiet pouring and also by the metal being red short. The existence of these two substances, carbon and iron oxide, shows that the carbon has no action on dissolved iron monoxide (FeO) or other iron oxide. If that is assumed, there is an explanation of the occurrences which take place when ingot iron cools.

If we assume that ingot iron is poured at 1,750 deg. C. and that in its saturated state it can dissolve 2 per cent of FeO, but really contains only 1 per cent, corresponding to 1,650 deg. C., it must be brought to the last-named temperature before the separation of the FeO can take place. At the moment of the separation of the iron oxide (perhaps only at the moment of separation) FeO is formed; the carbon commences to act thereon and to liberate carbonic acid. The steel becomes unquiet. It is known that such reactions of the FeO must be prevented, or the dissolved FeO must be destroyed. Formerly this was effected by the addition of manganese and silicon, with, however, the disadvantage that the products of oxidation of these substances remain in the ingot iron in a state of very great subdivision, as for instance a sort of emulsion. To prevent this, deoxidation must be effected with substances having gaseous oxides, that is, with carbon; but the other substances, as for instance oxide of manganese, must be given time to separate.

It is known that the basic slag resulting from the manufacture of iron contains dissolved iron oxides, and that these are reduced by the iron to monoxide FeO, which dissolves in the iron, even when this has been freed from oxygen. Thorough disintegration is possible only when the slag is freed from iron.

Can these conditions be fulfilled in the electric furnace? Eichhoff states that this is the case with the Héroult furnace, and that he doubts if it is so with the others.

Then comes the question if the electric process permits obtaining a greater chemical purity of the ingot iron, or does it permit, with impure raw material, the production of steel of a purity equal to that already produced, or greater than this?

For the Héroult process these questions can be answered in the affirmative. We must, however, remember that there can be removed from the iron only oxidable substances; as for instance phosphorus, sulphur, manganese, silicon, etc. Copper, nickel, arsenic, and the like cannot be removed. By the other processes the first-named set may be removed, but not to such an extent as by the electric, which permits reducing the percentage of phosphorus to 0.003 and that of the sulphur to less than 0.01. The removal of these substances does away with the injurious effect of the copper and arsenic, so it is not these, but other sulphur combinations, that do the damage. The oxidation here necessary can be effected only by the electric process.

Eichhoff states that he has made a charge consisting almost entirely of old bars, and from this got as results, phosphorus 0.003 per cent and sulphur 0.014 per cent.

The furnace for carrying out this process (seen in Figs. 6 to 9 inclusive) consists of a sheet-iron case lined with fire brick *H* and dolomite *K*. The rounded lower side of the bottom has two curved rails rocking in U-iron tracks. The cover has a wrought-iron frame and may be removed. The entire furnace may be trapped hydraulically. At the rear there are two electric motors *P*, which control arms *R*, on which there are fastened the electrodes *E*, which pass through the furnace roof, and which carry a single-phase 100-volt alternating current.

The distance of these from the upper surface of the bath is automatically kept at about 45 millimeters. This prevents carbonization of steel. Out of 1,000 charges, only once has there been any breakage or cracking in the electrodes; and only once has the charge been influenced thereby, while even in this case it was not ruined.

The process is as follows: 1,500 to 2,000 kilogrammes of steel is melted and more or less purified in a tipped Martin furnace of the Wellman type and then charged in the electric furnace. The bath is covered with an oxidizing slag, and the current turned on. After half or three-quarters of an hour the slag is carefully removed, the bath covered with carbon, and then a new slag, free from oxygen, put thereon. In twenty minutes this slag is melted and then the action of the electric arc thereon forms calcium carbide, effecting complete deoxidation. This keeps the bath perfectly free from the action of air. The addition of the neutral slag cools the bath so far that the greater part of the FeO is reduced by the carbon. At the same time with the neutral slag there is added a certain quantity of manganese ore, which is reduced, and which destroys the last small percentage of FeO. When the slag is perfectly white, a sample of the steel is taken and judged by its fracture for carbon percentage. Then a mixture of iron and carbon is added, and when this has been dissolved, the necessary quantity of manganese and ferrosilicon added, and the metal tapped off.

If the manganese ore has 50 per cent manganese, and 10 kilogrammes thereof (5 kilogrammes of manganese) are added, that will give for 1.500 kilogramme steel, 0.333 per cent manganese. If the steel is to contain 0.45 per cent manganese, then there must be added $0.45 - 0.33 = 0.12$ per cent $\times\ 1.500 = 1.8$ kilogramme manganese. If 80 per cent ferromanganese is used, there must be added $1.8 \div 80 \times 100 = 2.25$ kilogrammes of this ore. If the steel is to contain 0.3 silicon, and the ore contains 50 per cent silicon, there must be added $0.3 \times 1.500 \div 50 = 9$ kilogrammes. There is no manganese or silicon in the slag.

The analysis of the steel runs between 0.003 and 0.005 per cent phosphorus and 0.007 and 0.012 per cent of sulphur. The carbon, manganese, and silicon are usually kept between 0.03 and 0.05 per cent. The desulphurization takes place in the latter slag of the

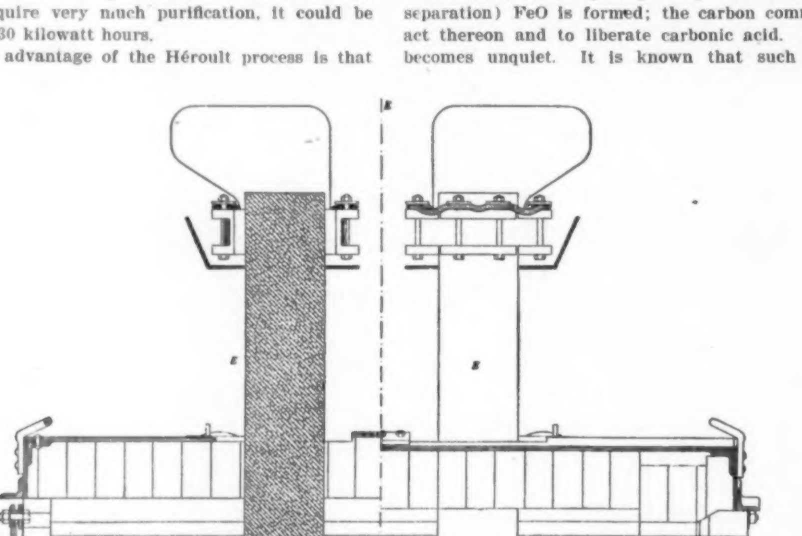


Fig. 9.—HÉROULT'S ELECTRIC FURNACE.

it is independent of the quality of the raw material; producing good steel from poor raw material.

There are two questions to be considered:

1. Deoxidation.
2. Complete purity.

All the methods now commercially used (with the exception of the crucible process) depend on the use of deoxidizing substances; and a thoroughly deoxidized steel must contain some easily oxidized substance like manganese to protect it from oxidation in remelting and casting.

The cause of the formation of blowholes in steel ingots is the presence of dissolved iron oxides.

If we follow the occurrences which take place in an ingot, we will usually see that the steel, at first quiet, afterward commences to be unquiet. It has been supposed that in the interior of the ingot iron oxide forms, and combines with the carbonic oxide which also collects there. If we have metal with 0.1 per cent of carbonic acid, which increases in the interior to 0.15 per cent, and that the iron contains x per cent of iron oxide, the metal would be unquiet in the ladle and in the mold, because of the proportion 0.150. According to Eichhoff, this explanation (xFeO) will not hold good. Iron monoxide FeO—or perhaps a lower oxide—is dissolved in the melted metal, in an amount depending on the temperature; for temporarily there is only an iron-carbon compound. If the curve here shown (Fig. 5) represents the solubility of the iron oxide, and we seek the point at which there would be none dissolved, we must find it in practice, as melted iron cannot be analyzed.

Referring to the puddling process, it is not known that weld iron (*Schweisseisen*) is red short by reason of dissolved iron oxide; so that we can say that there is no solution of iron oxide at the puddling temperature. If we assume this temperature to be 1,400 deg. C., the curve would commence at this temperature or take place in sudden starts, and that often cooling takes place, which at first is occasioned by special causes. This is explained by the fact that good melted ingot iron is free from pores on the otuside and contains holes in the inside only; and that often two or more rows of blowholes are found in the cold ingot. If the ingot iron were saturated with iron oxide, the separation of the latter would take place at once on pouring, and the block would have surface blowholes. But the metal dissolves not only iron oxide, but also gases. These do not separate as blowholes in pouring, but are exhaled by the steel; unless there are shocks tending to make them separate suddenly. Just as blowing air through water saturated with carbonic acid gas causes liberation of the latter, so separation of the carbonic acid from the ingot iron causes simultaneous liberation of the other dissolved gases.

In proof thereof Prof. Eichhoff states that if a test lot be taken from a Martin furnace when the charge is still very cold, it will often pour very quietly and forge well. If, however, the temperature rises and the charge is still somewhat hard, the quiet condition and the malleability cease. The steel falls in the ladle. If the charge is too soft, before it is hot enough, it is not sufficient to add gradually small amounts of pig to bring the charge to the original condition; large quantities must be added. It is only the cooling which causes the deoxidation of the steel, so the same result as with the addition of pig may be obtained by adding large quantities of soft scrap.

If a charge which is too soft stops boiling, it will start boiling again if soft scrap be added; that is, the scrap cools it, the iron oxide separates and is reduced by the carbon of the charge, carbonic oxide CO being formed. The favorable influence of charging with scrap in the Thomas converter after blowing is perhaps due to the same cause.

It is thus clear that to avoid blowholes the solution

process, and occurs because the slag can be kept more basic than by other processes.

If the charge is taken from the Wellman furnace in a very highly oxidized condition, it will contain only about 0.01 per cent of phosphorus, and can be covered at once with carbon and the natural slag, which will enable the charge to be made in one hour and a quarter with a power consumption of 200 kilowatt hours per ton of steel.

The great heat, instead of injuring the steel, is the cause of a very thorough disintegration and purification. As the bath is always in lively movement, no part is very hot a long time. The average temperature need not be greater than in any other furnace.

As far as the purity of the product is concerned, there is nothing left to be desired. The exactness with which any desired analysis may be attained is wonderful. The furnace roof lasts for 100 charges; the electrodes last 70 to 80 hours; that is, wear away at the rate of about 1 centimeter per hour. The average power consumption is about 250 kilowatts, that per ton of steel about 385 kilowatt hours.

The results of the practical work in the establishment of the Richard Lindenberg Company, Remscheid, Germany, are in general as follows, as shown by Guillot:

1. With the same degree of toughness the steel will stand 20 to 40 per cent more carbon and be that much more desirable.

2. It is remarkably ductile and contractile.

3. It is perfectly free from blowholes and surface faults.

4. It is perfectly deoxidized and contains no emulsions of silicon oxide or manganese monoxide.

5. So long as no sulphur is present, the percentage of copper and arsenic has no influence thereon.

6. No separation of phosphorus and sulphur takes place.

7. The steel is softer and forges better than crucible steel.

8. The cost of production is much less than with crucible steel.

9. The quality of steel produced is independent of that of the raw materials.

10. The manufacture is less fatiguing for the workmen than the crucible process.

11. The steel has a higher degree of purity than most crucible steel.

12. The process permits the production of any desired kind of steel alloy, even of analyses heretofore impossible to produce.

13. The melted steel may stand hours at a time under the neutral slag without alteration of quality.

14. Part of the charge may be drawn off and the rest made into another quality; which is very important in the case of ternary steels.

15. The steel may be allowed to solidify in the furnace and be remelted, without affecting its quality. This obviates all difficulty with "freezing," as with the Martin furnace.

The cost of manufacture varies according to conditions and the quality of the raw materials.

Each furnace requires two men and a boy. For cold raw material there may be needed, according to the size of the furnace, one or two more loaders. The consumption of electrodes is according to the size of the furnace and the temperature of the material charged; with cold charge it is marks 3 to marks 4 per ton; with liquid charge only marks 1 to marks 2.5. The loss in working is, in the case of the greatest degree of purity attained, 6 per cent for cold charges and 2½ per cent to 3 per cent for liquid. The consumption of lime and ore is not greater than with other processes; that of ferromanganese and ferrosilicon is less. The repairs and the consumption of fire brick and lining are less than with a Martin furnace.

If a liquid charge is used, this need not be purified in the Thomas or Martin plant; only blown through or over-oxidized.

The Héroult process is in operation in the following places:

La Praz, Isère, France, Société Electrométallurgique Française, 3-ton furnace.

Kortfors, Sweden, Aktiebolag Héroult Electrostahl, 4½ to 5 ton.

Remscheid, Germany, Richard Lindenberg Co., 1½ to 2 ton.

Remscheid, Germany, R. L. Co., for experiment, ½ ton.

Syracuse, N. Y., Halcomb Steel Company.

Héroult furnaces are in operation in the following places in April, 1907:

Judenburg, Austria, Danner & Co.

Schaffhausen, Switzerland, Fischer.

Saut du Tarn, France.

Other furnaces are planned in America.

AMOUNT OF AIR NEEDED FOR VENTILATION.*

A FEW PRACTICAL HINTS.

BY F. H. BRYANT.

Under the general conditions of outdoor air, namely, 70 degrees temperature and 70 per cent complete saturation, an average adult man, when sitting at rest in an audience, makes sixteen respirations per minute. The air thus inhaled will consist of about one-fifth oxygen and four-fifths nitrogen, together with about 1.7 per cent aqueous vapor and 4/1,000 of 1 per cent carbonic acid. By the process of respiration the air will when exhaled be found to have lost about one-fifth of its oxygen by the formation of carbonic acid, which will have increased about 1/100 fold, thus forming about 4 per cent, while water vapor will form about 5 per cent of the volume. In addition, the inhaled air will have been warmed from 70 to 90 degrees, and, notwithstanding the increased proportion of carbonic acid—which is about one and one-half times heavier than air—will, owing to the increase of temperature and the levity of the water vapor, be about 3 per cent lighter than when inhaled. Thus it will be seen that this vitiated air will not fall to the ground, as has often been presumed, but will naturally rise above the level of the breathing line, and the carbonic acid will immediately diffuse itself into the surrounding air. In addition to the carbonic acid exhaled in the process of respiration, a small amount is given off by the skin. Furthermore, one and one-half to two and one-half pounds of water are evaporated daily from the surface of the skin of a person in still life. If the air supply at 70 degrees is assumed to have a humidity of 70 per cent and to be saturated when it leaves the body at a higher temperature, then at least four cubic feet of air per minute will be required to carry away this vapor.

Taking into consideration these various factors, it becomes evident that at least four and one-half cubic feet of fresh air will be required per minute for respiration and for the absorption of moisture and dilution of carbonic acid gas from the skin. This, however, is only on the assumption that any given quantity of air, having fulfilled its office, is immediately removed without contamination of the surrounding atmosphere; but this condition is impossible, for the spent air from the lungs, containing about 400 parts of carbonic acid gas in 10,000, is immediately diffused in the atmosphere. The carbonic acid does not fall to the floor as a separate gas, but is intimately mixed with the air and equally distributed throughout the apartment.

It must then be evident that ventilation is in effect but a process of dilution and that when the vitiation of the air discharged from the lungs is known and the degree of vitiation to be maintained in the apartments is decided, the necessary constant supply of fresh air to maintain the standard may be very easily determined. For the purpose of calculation, 0.6 cubic foot per hour is accepted as the average production of carbonic acid by an adult at rest and the proportion of this gas in the external air is four parts in 10,000. If, therefore, the degree of vitiation of the occupied room be maintained at, say, six parts in 10,000, there will be permissible an increment of only two parts in 10,000 above that of the normal atmosphere, or 2/10000—0.0002 of a cubic foot of carbonic acid in each cubic foot of air. The 0.6 cubic foot of carbonic acid produced per hour by a single individual will, therefore, require for its dilution to this degree 0.6 divided by 0.0002, or 3,000 cubic feet of air per hour. Upon this basis the following table has been calculated.

The figures indicate absolute relations under the stated conditions, and are generally applicable to the ventilation of schools, churches, halls of audience and the like, where the occupants are reasonably healthy and remain at rest. But this absolute air volume to be supplied cannot be specified with certainty in advance, without a thorough knowledge of all the conditions and modifying circumstances—in fact, the climate, the construction of the building, the size of the rooms, the number of occupants, their healthfulness, and their activity, together with the time during which the rooms are occupied, all have their direct influences. Under all these considerations it is readily seen that no standard allowance can be made to suit all circumstances, and results will be satisfactory only in so far as the designer understandingly, with the knowledge of the various requirements as they have been given, makes such allowance. The following schedule of air supply, in cubic feet per hour, as proposed by Dr. Billings, is here presented as showing relatively the volumes recommended by him in different classes of buildings:

Cubic Feet of Air Containing 4 Parts of Carbonic Acid in 10,000 Supplied per Person.		Degree of Vitiation of the Air in the Room, Parts of Carbonic Acid in 10,000.
Per Hour.	Per Minute.	
6000	100.0	5.0
4000	66.6	5.5
3000	50.0	6.0
2400	40.0	6.5
2000	33.3	7.0
1800	30.0	7.33
1714	28.6	7.5
1500	25.0	8.0
1200	20.0	9.0
1000	16.6	10.0
546	9.1	15.0
375	6.2	20.0
231	3.8	30.0

	Cubic Feet per Hour.
Hospitals	3,600 per bed.
Legislature assembly halls	3,600 per seat.
Barracks—bedrooms and workshops	3,000 per person.
Schools and churches	2,400 per person.
Theaters and ordinary halls of audience	2,000 per seat.
Office rooms	1,800 per person.
Dining rooms	1,800 per person.

These figures are for buildings in which there is no special contamination of the atmosphere beyond that which their use would indicate. When there are smoke, dust, noxious gases, a four and one-half gas burner demands forty-five cubic feet of air per minute, and the resulting carbonic acid gas, unless sufficiently diluted, or immediately removed, will seriously vitiate the air. The introduction of modern methods of incandescent electric lighting has done much to simplify and facilitate the solution of problems in heating and ventilating.

The air volumes recommended for ventilation by various investigators of the past century show a constant increase in their quantity as the years progress. As good ventilation is only a relative term, depending largely on one's experience and the possibility of improvement, it must be evident that perfect ventilation in the broadest sense can only be secured in the open air. It is, therefore, the province of ventilation to approach as near this perfection as means and expediency will permit.

The crystallization of public opinion into statute laws, looking to adequate methods of ventilation for school, theater, church, and factory, has resulted in the establishment of a basis or limit which will meet the approval of those upon whom is placed the responsibility of enforcing these laws. Under the law as first passed in Massachusetts, the attempt was made to secure fifty cubic feet per head per minute, but it was soon discovered that such provision would necessitate the remodeling of practically every building in the State. The limit was dropped to thirty cubic feet, a figure adopted not because of hygienic deductions, but because it appeared upon investigation to be the practical limit attained by existing methods in the commonwealth.

The basis of thirty cubic feet has been very generally adopted throughout the country, and is to-day recognized as the minimum volume to be provided in any system of ventilation worthy of the name. As the benefits of good ventilation are still further recognized, and the ability of the fan to provide practically unlimited volumes of air is better appreciated, this limit will gradually rise until we may one day witness the compulsory provision of air for the purpose of ventilation in such volumes as to render improvement of no practical benefit.

* Abstracted from the Architect and Engineer.

Ink for Ivory.—Free the ivory from fat by allowing it to steep in a strong soap solution and afterward washing it off. Normal ink, made from nitrate of silver 10 parts, distilled water 100 parts is used. Divide into 10 equal parts. Leave No. 1 unchanged. Mix No. 2 with an equal quantity of water. No. 3 with double the quantity of water, etc. Each of these inks produces a special shade of color. When for drawings, a warm, brown gold shade is desired, the object must be placed in a solution of chlor-aurate of sodium 1 part and 100 parts of water and after some time in a solution of 1 part hyposulphite of soda in 10 parts of water.

SAND WAVES AND THEIR WORK.

THE RAVAGE WROUGHT IN THE DESERT

BY DAY ALLEN WILLEY.

The formation of sand hills or sand dunes along the Atlantic seacoast of the United States is so frequent, that these eminences are common sights, especially on Cape Cod peninsula, the coast of New Jersey, as well as in the vicinity of Cape Henlopen, Cape Henry, and on the beaches of North and South Carolina. It is perhaps unnecessary to say that the dunes are created by the action of the wind upon the sand, which is washed up by the waves. They are termed fixed or wandering dunes according to their formation; for unless one is sufficiently covered with vegetation, the force of the wind currents continually changes the position of the sand to such an extent, that the hill travels in the direction of the prevailing breezes at a rate depending upon their force and constancy. Measurements which have been taken in southern New Jersey, as well as Massachusetts, show that in a year a wandering dune may move from 15 to 20 feet. Unfortunately, the sand is continually shifting to such an extent, that there is little opportunity for seed which may be deposited upon the surface to germinate; and even where shoots appear above the surface, unless protected in some manner they are soon killed by being covered over or cut off by the contact of the flying sand particles. Consequently, the movement of a shifting dune is seldom checked until it has changed its location to such a point that it is less exposed to the wind current, when it may become fixed by the growth of vegetation upon it. The formation of the coast dune has a parallel in the sand waves, as they are termed, which are found in various localities inland, since they are due entirely to the action of the wind currents on loose material of this kind; and where the topography is favorable, so many waves are formed that they have been termed sand seas, as one can see ridge after ridge reaching backward for miles, and bearing a striking resemblance to the waves of the ocean. Not only in the United States are to be noted examples of this kind, but in some portions of the Sahara in Africa, and especially in the Turkestan desert, although the valley of the Columbia River in Oregon and Washington probably contains as remarkable illustrations of the action of the wind as any part of the world. Picturesque as is the view along these sand ridges, unfortunately they afford a perplexing problem for residents in this vicinity to solve, as they frequently overwhelm the railroad tracks, and would engulf buildings if steps were not taken to prevent their encroachment. For a considerable distance the tracks of the railway owned by the Oregon Railroad and Navigation Company are built through this valley between the Dalles and Wallula. Such is the movement of the sand, that on a windy day it is literally impossible to keep the tracks clear of the drift by means of shovels, and unless extraordinary measures were taken, the railroad would soon become buried to a depth of many feet.

Illustrated London News.

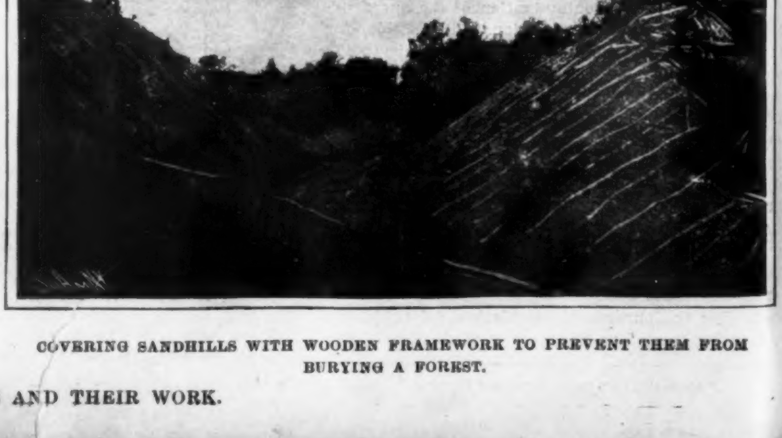
AMONG THE BREAKERS OF THE SAHARA "OCEAN OF SAND."

An excellent opportunity has been given in the Columbia Valley to study the exact effect of wind currents blowing in different directions, since the high bluffs cause eddies and miniature whirlwinds, which also act upon the sand, as well as what might be called the direct currents. The changes made in the sand waves by various forms of barriers have also been carefully studied, and as a result some valuable data hav been secured. It has been found that when the wind sweeps over a free surface of drifting sand, it acts about equally throughout; but an obstruction of any kind, such as a log or a bunch of grass, at once modifies the action of the wind. A solid object increases the force of the wind around the sides, and hence the sand is excavated. In the lee of the object the sand will accumulate. If two such obstructions are near together, a channel is formed between them, and once formed deepens with astonishing rapidity. The carrying power of the wind increases much more rapidly than the increase in the velocity. Consequently, any increase in the velocity is immediately noticeable in the increased erosive power. The erosive power of the wind is not identical with the carrying power, for in the first case the wind overcomes cohesion, and in the second case it overcomes weight. If the velocity of the wind decreases, the sand previously held in suspension is deposited. Thus if a solid fence is placed upon the sand at right angles to the wind, the sand is excavated in front. The wind, unable to proceed, is divided into currents in all directions. Those going downward scoop out the sand, thus forming a drift a short distance in front. This increases until its height equals that of the fence, when the wind, no longer meeting with the obstruction, allows sand to be deposited in this channel, and it fills up, covering the fence. Similarly, at the ends of the fence the wind currents are increased, and the sand is scooped out. If the fence is raised so as to allow a space beneath, the sand is rapidly scooped out below. The same result occurs beneath buildings, trestles, or other works which allow a space beneath, through which the wind rushes with increased force. If, however, the obstruction is not solid, but more or less open, as a pile of brush or a bunch of grass, the action is entirely different. The wind passes through the obstruction, but with decreased velocity; hence sand is deposited within the obstruction. No excavation takes place in front or around the sides. If the obstruction is stiff and inflexible like a sand fence, the sand is deposited on both sides, the windward slope bein' gradual and the lee slope more abrupt. If the obstruction is flexible like a bunch of grass, most of the sand is deposited in the lee. Of course, there are all gradations between the two classes, and various circumstances may modify the usual action.

It has also been ascertained, that when the wind is blowing up an incline, the surface velocity increases with the steepness, but when the wind blows down a slope, eddies form, which usually produce a current uphill at the surface. Thus it happens that while small bodies can be blown uphill easily, it is not often that they are blown downhill, but must fall from their own weight when the slope is steep. The fact that the velocity of the wind at the surface on the windward side of a dune increases with the slope results in producing a normal incline, which represents a balancing of forces. Usually this incline is quite gradual compared with the lee side of the dune, where the slope is the greatest at which the sand will remain in place—about 30 deg.

The Columbia River, which deposits the sand along the valley it traverses, often rises to a height of fully 60 feet during the freshet season, carrying down stream an immense quantity of fine silt, which is more mobile than the ordinary sea sand, as it consists of very fine rounded grains, easily combined into drifts by the strong winds which sweep through the valley. The movement of the wave is of course caused by the movement of the sand grains over its crest. As the direction of the winds is generally upstream, the waves have a notable uniformity, and at times attain

WOOD BREASTWORKS FOR FIGHTING THE SAND.



COVERING SANDHILLS WITH WOODEN FRAMEWORK TO PREVENT THEM FROM BURYING A FOREST.

SAND WAVES AND THEIR WORK.

such a height that actually trees 40 feet in height are sometimes buried to the tops. An analysis of the sand shows that it is very fertile when sufficiently irrigated, but the high winds absorb so much moisture that it is impossible for vegetation to take root in the dry season.

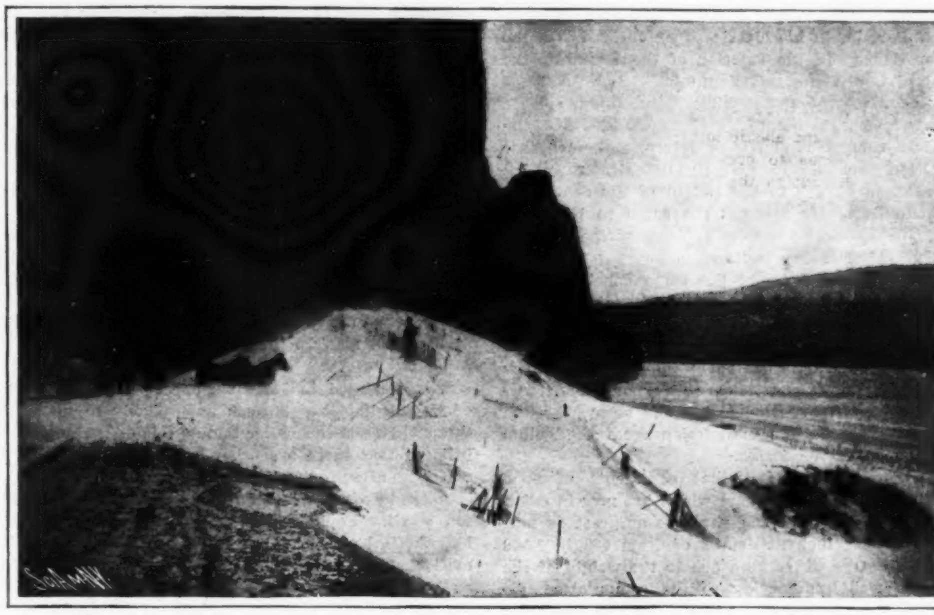
In fighting the sand sea, several methods of checking the movement of the sand have been tried, some of them with notable success. The first and most extensively used is the "sand panel." A panel consists of two boards, 1 inch thick by 12 inches wide, and about 20 feet long, nailed to sharp stakes at each end. The stakes are driven into the sand, so as to make the panel stand up with its length oblique to the wind, and the leeward end away from the track. The wind is thus made to carry the sand along the face of the boards and away from the track. While the wind is blowing hard, the panels must be closely watched, as they soon become undermined and fall down, or if not properly placed, are covered up. The second method can be used only where there is a considerable level space on the leeward side of the track. A vertical wall of inch boards from 10 feet to 20 feet high is built a few feet to windward of the track, with an opening of 3 feet or 4 feet at the bottom. The wind striking the wall is turned down, and passes with increased velocity through the opening at the bottom, carrying the sand with it, but soon loses its force on the lee side of the wall, and deposits the sand just across the track. From there it must be occasionally removed by teams or some other means.

A third method, invented by Mr. J. P. Newell, is a modification of the panel plan, but is intended to be of permanent construction. A tight wall from 10 feet to 16 feet high, composed of two planes, the upper inclined toward the wind and the lower away from it, is built between the track and the approaching sand drift. The upper plane deflects the air current strongly downward, and the lower one throws it out so that it cannot undermine the walls, but is turned against the sand bank. The wind is thus made to carry the sand along the wall to the end, which is located at some point where the natural features will prevent the sand from doing any harm. Such a wall has protected one of the worst places on the road for three years. The movement of the sand has also been partly obstructed by the planting of trees at right angles to the direction of the waves. The trees, which are of a variety which will take root in the formation, are usually set out in two rows separated by a bank of sand, but the formation about them must be artificially moistened to keep them from dying.

As the photographs show, however, there are places where apparently no protection is sufficient to keep the sand from covering the right-of-way. At one point where the track passes close to the wall of rock forming one side of the valley, a force of men and teams is almost constantly employed with shovels and scrapers as illustrated.

As far back as 1832 the people of Massachusetts realized the necessity of preventing the movement of sand dunes near some of the coast towns, to prevent the latter from being literally overwhelmed. The principal form of protection has been the planting of beach grass in places where the wind currents are not too violent to check its growth, keeping the dunes from forming. Some of the dunes have also been "fixed" after formation by planting the grass, then protecting it from the wind by covering the windward side of the hill with brushwood. On a fixed dune certain kinds of trees will grow to maturity. This is illustrated by the forests in New Jersey and Virginia, some of which extend almost to the water's edge. In these States, however, are places where the dunes have reached a height of over 100 feet, and have literally buried growths of large timber to such an extent, that only a few feet of the trees can be seen projecting from the sand here and there.

Near Cape Henry there are shifting dunes, which are gradually engulfing pine woodland in their rear, since this section of the coast is exposed to the severest gales which sweep over the Atlantic in winter. One of the most notable illustrations of shifting dunes, however, is to be seen at Cape Henlopen, Delaware. Here the lighthouse, one of the highest towers on the seaboard, is nearly surrounded by a ridge of sand, which already reaches more than half way to the top. The resistance to the wind, however, has caused eddies, which have prevented the sand from closing in around the structure, except on one side. From Delaware Bay the size and height of the building can be appreciated, but looking at it from the southeast, from which come the principal winds, the tower appears to be only about 20 or 25 feet above the shore.



RAILROAD MEN FIGHTING THE SAND SEA IN OREGON. THE TRACK CAN BE SEEN TO THE LEFT PARTLY BURIED.

THE EARTH A FAILING STRUCTURE.*

By JOHN F. HAYFORD.

THE earth is a failing structure. Stresses are set up within it by many forces. It is yielding to those forces and is being deformed beyond its elastic limit. The yielding certainly occurs every year, and probably every day and every hour.

A competent structure may be defined as one which bears the stresses brought to bear upon it without permanent injury to itself. When a competent structure is unloaded it returns to its original shape and size by virtue of its elasticity. Its deformation while loaded is fixed by the elastic constants of the material. A steel bridge under normal conditions carrying safe loads is a good illustration of a competent structure. Under every additional pound of load applied it moves to a new position. It responds to every shifting of the loads upon it. Every motion is governed by the laws of elasticity. When the loads are removed, the bridge goes back accurately to its former shape and position, and is without any discoverable difference in any respect from its state before being loaded.

The characteristics of a failing structure may be best illustrated by the well-known behavior of a piece of bridge steel being tested to destruction, under tension, in a testing machine. Suppose that successively larger loads are applied and removed. In the earlier stages of the test, as long as the loads are within the elastic limit for that material, the elongation of the piece is proportional to the load and independent of the duration of the application of the load. Under each new load the piece takes a new length promptly and maintains it unchanged as long as the load does not change. The piece returns to its original length promptly when the load is removed. The piece is a competent structure under these loads.

As soon as a load is applied which is slightly beyond the elastic limit, the behavior of the piece is very different. The elongation is no longer proportional to the load. It increases with the lapse of time under the load as long as the load is maintained. When the load is removed, the piece returns only part way to its original length. It has acquired a permanent set, a permanent deformation.

When a load much in excess of the elastic limit is applied, the stretching under the load is more rapid, and a new feature of the failure begins to appear. When the piece was a competent structure, the elastic elongation was distributed throughout the piece, following a perfectly regular law. When the piece is failing under loads slightly beyond the elastic limit, the stretching is somewhat irregularly distributed through the piece. When the loads are long-continued and much beyond the elastic limit, the stretching concentrates gradually at the immediate vicinity of the weakest point of the piece. The degree of concentration of the damage increases until, just before the complete failure occurs, practically all of the distortion is taking place in the immediate vicinity of the point at which the rupture is to take place.

There are two contrasts which it is important to keep in mind between the behavior of this failing test-piece and of failing structures generally, on the one hand, and the behavior of an elastic competent structure, on the other hand.

First, the yielding of an elastic competent structure is independent of the length of time the stresses are in action. It depends solely upon the elastic constants and the inertia of the material. The bridge engineer in designing his competent structure does not consider the length of time the loads are to be applied. On the other hand, the yielding of a failing structure increases with the lapse of time; it is very slow if the stresses are but little in excess of the elastic limit, and is faster the greater the excess of stress beyond the elastic limit. To predict the behavior of a failing structure, it is necessary to know how much the stresses exceed the elastic limit of the material and how long they continue to be beyond that point.

Second, in a competent structure the distribution of

* Read before the Philosophical Society of Washington.

SHIFTING DUNES BURYING A FOREST.

WOODLAND DESTROYED BY SAND.

HOUSE BURIED IN THE SAND SEA.

SAND WAVES AND THEIR WORK.

the yielding or distortion does not change with increase of load or lapse of time. With double the load applied at a given point, every part of a competent bridge yields by a double amount. On the other hand, the distribution of the permanent yielding or distortion in a failing structure is continually changing. The damage tends more and more strongly to concentrate at the weakest point or points as failure progresses.

G. H. Darwin, in his classic paper entitled "On the Stresses Caused in the Interior of the Earth by the Weight of Continents and Mountains,"* has furnished a very good way of approaching the question, "Is the earth a failing structure?" He assumes that the earth is a competent elastic structure, and upon that assumption proceeds to compute the stresses which must exist in it, due to the weight of the continents and mountains. He assumes the earth to be homogeneous in its elastic properties from surface to center. The material forming and underlying the continents is assumed to be of the same density as the material beneath the oceans. The computation is made under a sufficiently complete theory of elastic deformation to take account of the support which each portion of the material in the earth obtains from all the surrounding material. It takes into account the transmission of stress, by compression and shear, through the solid sphere in every direction from the points of application of the forces.

The computation shows that continents of such dimensions and form as those which are now in existence would produce stress-differences as great as four tons per square inch at depths of from 600 to 1,000 miles. The stress-differences due to the weight of the continents would, according to the computation, decrease both downward and upward from a maximum value at a depth of from 600 to 1,000 miles, becoming zero at the center and approaching zero at the surface. The stress-difference at 70 miles below the surface, according to the computation, is about one ton per square inch.† The computation, based on the assumption stated, also shows that parallel mountain ranges of density 2.8, rising 13,000 feet above the intermediate valley-bottoms, would produce stress-differences of 2.6 tons per square inch.

The statement that the stress-difference is four tons per square inch at a given point within the earth means that at that point the compressive stress is four tons per square inch greater in the direction of maximum compressive stress at that point than it is at that point in the direction of minimum compressive stress. This form of statement eliminates any reference to the actual compressive stress in either direction. It is stress-difference which tends to deform and rupture the material, not hydrostatic pressure. A stress-difference of four tons per square inch corresponds in its effect to a compression of four tons per square inch applied to two faces of a cube in a testing machine while the other four faces of the cube are left free from pressure.

Darwin's conclusion, as stated in his paper, is that since such continents exist, since they do not sink down, or the sea bed rise up, the materials composing the earth are strong enough to bear the computed stresses. For example, he writes: "From this discussion it appears that if the earth be solid throughout, then at a thousand miles from the surface the material must be as strong as granite." He states in a table the breaking stress-difference in granite to be from 2.45 to 4.91 tons per square inch.

Let us take Darwin's computations, and reason from them in another way. Instead of deducing from the computations the strength of the materials composing the earth, let us take some of the known facts as to the behavior of materials under stress at the surface of the earth, and endeavor to estimate whether the material composing the earth probably would bear, without permanent deformation, the stresses brought to bear upon it by the continents and mountain ranges.

When the subject is approached from this point of view, at least six reasons appear for believing that the material would undergo permanent deformation:

1. It may be doubted whether even granite will stand for geologic ages, without permanent deformation, a stress-difference as large as four tons per square inch. This is the breaking stress-difference of a good granite, according to the figure given by Darwin. All materials begin to suffer permanent deformation at an elastic limit considerably less than the stress-difference necessary to break them. The longer the period of application of the stresses, the farther the effective elastic limit falls below the breaking stress-difference. In the case in hand the stresses exist continuously for geologic ages. A standard authority on engineering practice gives the safe working load for granite masonry at 30 tons per square foot, or one-fifth of a ton per square inch, and states that this is about the maximum in existing structures. According to Darwin, the material within the earth must stand for geologic ages a stress-difference of four tons per square inch—twenty times as great as the safe load prescribed by engineers for granite—or it must fail.

2. Granite is one of the strongest of the materials found abundantly in the accessible part of the earth's crust. One may well doubt whether the heterogeneous mixture composing the crust is as strong on an average as continuous good granite.

3. Failure—that is, permanent deformation—at any point tends to concentrate further failure at and near that point. The heterogeneous mixture of material composing the earth probably has many spots of weakness in it which will tend to cause failure long before the stronger material gives way. The stress-differences at which failure will commence therefore depend upon the strength at the exceptionally weak spots in the material rather than upon the average strength of the material.

4. The materials composing the earth's crust, except those near the surface, are subjected to high temperatures, which tend to reduce their strength. The temperature at 70 miles below the surface probably exceeds 1,900 deg. C.—above the melting point of iron and many other materials, under surface conditions.

5. It is stated in Darwin's paper that one at least of the assumptions is such as probably to make the computed stresses smaller than the fact.* The speaker believes that there are other implicit assumptions, to which no attention is clearly called in the paper, which also tend to make the stresses computed by Darwin too small. For example, Darwin has dealt with a hypothetical continent represented by a regular mathematical form. His hypothetical continent resembles, as he states, an actual continent after its irregularities have been supposed smoothed out by leveling down the mountains and filling in the valleys. The stresses due to such a hypothetical smoothed-out continent are less than those due to an actual irregular continent. He has also computed the stress-differences due to ranges of mountains not much greater than some of the actual ranges which exist on the continents and has found the stress-differences nearly two-thirds as large as those due to the smoothed-out continents. In nature the two sets of stresses, those due to smoothed-out continents as a whole and those due to separate mountain ranges, exist at the same time in combination. The stresses are not in general combined by a mere algebraic addition. Nevertheless the combined stress-difference due to both at any one point is in general larger than the stress-difference due to either one alone.

6. As stated in Darwin's paper itself, if the earth is not solid throughout, if the outer solid crust is less than two or three hundred miles thick, the stress-difference must be much greater at some points within the crust than the value computed by him, namely, four tons per square inch. Now, in so far as any effect on the stresses above that depth is concerned, the part of the earth below a given depth is an exact equivalent of a liquid, if at that depth hydrostatic equilibrium exists—that is, if the pressure in all three directions is the same at each point at that depth. Now, many different men, reasoning from various points of view, have each reached the conclusion that a liquid condition, or its equivalent in the sense just indicated, is reached at a depth less than 200 miles.

For all these reasons, then, it appears probable that under the stress-differences within the earth due to the weight of the continents and mountains, the material must slowly yield, the continents slowly sink downward, and the ocean bottoms rise.

One apparently invincible argument against this conclusion is thus stated in Darwin's paper: "The interior of the earth must be in a state of stress, and as the land does not sink in, nor the sea bed rise up, the materials of which the earth is made must be strong enough to bear this stress." But the premise of this argument ignores the overwhelming mass of evidence accumulated by the geologists, that large portions of the present surface of each continent have at some time been at or below sea-level. Changes in elevation in the material composing the continents are put in evidence everywhere by geologic structure and topographic forms. The continents are in the habit of sinking and rising. We must therefore draw the conclusion, apparently contradictory to Darwin's, that the materials of which the earth is made are not strong enough to bear the stresses to which they are subjected.

This conclusion is not necessarily contradictory to Darwin's conclusion, for the reason that the stresses which cause the continents to rise and fall may be due to some other cause than gravity.

The principal conclusion reached from Darwin's paper, as supplemented, is that if the material forming and underlying the continents is of the same density as the material beneath the oceans, the earth is probably a failing structure; that it is slowly yielding under the stresses, the continents sinking and the ocean beds rising. Please note that, on this evidence alone, the yielding is stated to be a probability, not a certainty. Because of the uncertainty, it is desirable to examine all available lines of evidence.

The theory that there exists in the earth the state of approximate equilibrium called isostasy has an important bearing upon Darwin's paper. According to the theory of isostasy, the material forming and underlying the continents is less dense than that under the oceans, whereas in Darwin's computations the densities were assumed to be the same. Pendulum observations have long been known to indicate that isostasy exists. The originator of the word "isostasy," C. E. Dutton, based his belief in isostasy on geologic evidence and pendulum observations.* Other geologists have considered that the evidence before them indicates isostatic readjustment to have occurred. I have elsewhere presented some of the geodetic evidence which proves that, at least for the United States, there is a rather close approach to the isostatic conditions.†

To the extent that it is proved that isostasy exists, that the continents are lighter, and the ocean beds denser than assumed by Darwin, it is also proved that the stresses within the earth are less than his computations would make them. At first sight, apparently, it is also proved that there is decreased reason for supposing the earth to be a failing structure; but further consideration of the evidence in regard to isostasy, combined with geologic evidence, as indicated in the following paragraph, shows that, instead of concluding that the stresses are small, and that therefore the earth is not failing, we should conclude that the earth is failing under stresses even smaller than those we had believed to exist; that the earth is weaker than we had supposed.

The geologic evidence is overwhelming that within the interval of time covered by the geologic record many thousands of feet of thickness have been eroded from some parts of the earth and have been transported to and deposited upon other parts. If isostatic readjustment had not also been in progress during this interval, it would be impossible for the isostatic compensation to be so nearly complete as it is now known to be in and around the United States. By isostatic compensation is meant the compensation of the excess of matter at the surface (mountains, continents) by defect of density below, and of surface defect of matter (valleys, oceans) by excess of density below. Isostatic readjustment can only take place in two ways: It may take place by actual transfer of material beneath the surface. It may take place by change of density of matter without transfer of that particular matter—that is, by increase or decrease in volume of given masses. In either of these cases, or in any combination of them, there is permanent deformation of the material, a yielding to applied stresses, and we are led again to the idea that the earth is a failing structure.

If the earth is now and has long been a failing structure, the material accessible at its surface should bear the evidence of that fact in recognizable form, just as the twisted mass of steel on the bank of the St. Lawrence bears in itself easily recognizable evidence that a bridge has failed near Quebec. The material composing the earth's surface does bear the evidence, and the evidence has been described by thousands of men. If one consults the literature of geology, and especially that portion of it which sets forth directly the facts which have been observed, rather than the generalizations from them, he finds everywhere descriptions of faulting, of warping of strata, of folding of strata, of overthrusts, of intrusions, of vulcanism, of uplift, of subsidence. All these are evidence of past failure, of permanent non-elastic yielding to applied stresses. The only parts of the earth's outer crust where such evidence has not been found are apparently the parts of the land surface in which there has been little or no geological exploration, and the ocean bottom, where the evidence would be extremely difficult to detect.

Moreover, the geologic evidence shows that these yieldings have occurred at various epochs throughout the whole interval of time covered by the geologic record written in the rocks, and that the yielding, at least in some cases, has been gradual rather than sudden. In whatever area on any continent a geologist works he finds this evidence, and, so far as I am able to judge, it appears that the more a given area is studied, the more conclusive is the evidence that permanent deformation under stress has there taken place. Just as the geologist who studies cubic miles of the earth finds abundant evidence of past failure, so also does the geologist who studies cubic

* Philosophical Transactions of the Royal Society of London, vol. 173, 1882, pages 187-230.

† Scaled from Fig. 6, plate 20, of Darwin's paper.

* See, especially, the statement in regard to the figure of equilibrium, on page 225 of the paper.

* C. E. Dutton: "On Some of the Greater Problems of Geology." Bulletin of the Philosophical Society of Washington, vol. xi., pp. 51-64.

† John F. Hayford: "The Geodetic Evidence of Isostasy." Proceedings of Washington Academy of Sciences, vol. viii., 1906, pp. 25-40; and also "Geodetic Operations in the United States, 1903-06," a Report to the Fifteenth General Conference of the International Geodetic Association, by O. H. Tittmann and John F. Hayford.

millimeters of rock under the microscope find similar evidence in the structure of the rock.

One of the characteristics of a failing structure is that where failure begins, there later damage tends to concentrate. The point of initial failure in the Quebec Bridge was first located mainly by noting that two of the main members of the bridge had suffered much more distortion than the others. So, if the earth is a failing structure, we should expect to find indications that progressive and concentrated failure has occurred at some places rather than that the failure has been uniform in degree in all parts. Such indications exist and have frequently been recognized and commented upon. It is recognized by geologists generally that there are regions of excessive deformation, as if some incipient weakness had concentrated failure there, and that there are other regions in which the deformations have been moderate in amount, as if those were regions of more than average strength in a failing structure. Where mountain-building commences, there it tends to continue for a long time, though not, perhaps, for an indefinite time. Ocean bottoms and great plains apparently tend to remain ocean bottoms and plains.

The motions at the earth's surface due to earthquakes, which are detected by seismographs, are vibrations of small amplitude, having periods of a few seconds, as a rule. The fact that these vibrations persist for a considerable time, for minutes or hours, and that they not infrequently travel all the way around the earth, and at least part of a second trip, show that, under these particular applied forces, the earth acts as a highly elastic body. The observed rate of propagation of the wave, combined with the known density of the material through which the wave is propagated, enables one to compute the rigidity. Such computations have been made. But the rigidity is simply the relation between the applied force and the distortion produced. It is the stiffness. Such computations furnish no information in regard to strength. As soon as one considers the stresses involved, at points remote from the source of an earthquake, it is evident that they are insignificant as compared with the elastic limit of the material.

I conceive the earth to be a failing structure, slowly yielding to the forces acting upon it. I conceive that, at the source of an earthquake, stresses having accumulated to the breaking limit, a fracture occurs, and there is sudden movement, causing, as a rule, various other fractures at near points. From all these points of fracture elastic vibrations start out in every direction, and progress until they die out on account of internal friction; and this may not be until the vibrations have traversed the whole earth. This conception of elastic vibrations traversing a failing earth, which is at the same time slowly yielding in a non-elastic manner to other stresses, contains an apparent contradiction which is, however, not real.

It is not uncommon nor mysterious for a mass of material to respond with elastic vibrations to suddenly applied forces, while at the same instant it is yielding in a non-elastic manner to forces applied steadily without change of direction. A large mass of cold pitch will resist a light blow of a hammer, while at the same instant it is slowly yielding and flowing under the comparatively small stresses due to its own weight.

In the deep copper mines of the northern peninsula of Michigan the behavior of the whole earth, with respect to earthquakes and stresses due to other causes, is well illustrated on a small scale. At certain times during each day blasts are set off in the solid rock at various places in each mine. Each battery of blasts is a miniature earthquake. In that particular spot, the earthquake center, the rock is fractured within a space limited by a radius of a few feet. Within a large space, limited by a radius of a few hundred feet, elastic vibrations are set up in the solid rock which are sufficiently violent to be perceptible to the touch and to the hearing. Within this larger space no fracture of the rock occurs. Feebler vibrations doubtless extend out for miles from the point of fracture, just as vibrations extend over the whole earth from an earthquake center. Now it also happens that in the lower levels of these deep mines, at a mile below the surface of the earth, the solid rock is slowly yielding, in a non-elastic manner, under the influence of the great weight above it, so that the larger openings are gradually closing up. This is so clearly recognized and progresses so rapidly that it is proposed as routine practice,* at the deep levels in these mines, to take out the ore at the distant end of each drift first. The miners will then work back slowly toward the shaft from which the drift is entered, while the spaces in which they have recently labored gradually close up behind them. The gradual collapse known to be in progress occurs apparently by imperceptible flow and by minor fracturing, but not, as a rule, by catastrophes which close up any opening suddenly. In this respect it is an epitome of what is taking place every year in the failing earth as it yields under such stresses, due to gravity and other causes, as are applied for long periods without changes of sign. The solid rock near each large opening in the mine responds to every blast in the mine by elastic vibrations; and yet, at the same instant, that same rock is yielding in a non-elastic manner to the stresses due to gravity.

It is not necessary to go a mile below the surface of the earth to find non-elastic slow yielding. It is commonly known to miners working in mines of ordinary depth.

Each earthquake is evidence that at a particular point or region at that particular time the earth is failing. As the sensitive seismographs now in operation show that there are hundreds of earthquakes each year, the sum total of such failure is not small. But I repeat that the observations of earthquakes furnish little or no evidence of the absolute strength of the earth; for in or near each earthquake center, where the test of strength occurs, no accurate observations are ordinarily secured. Outside the region in which the test of strength takes place, seismographs secure a record of the elastic vibrations, and thus secure evidence as to the earth's rigidity—its stiffness, but not its strength. If the elastic vibrations were recorded by a seismograph so close to an earthquake center that the stresses during the vibration approached the breaking limit, then some information as to the strength might be secured; but such a fortunately located seismograph is so badly shaken that it furnishes no readable record.

If the earth is a failing structure; if throughout considerable portions of its mass the stress-differences are so great that the material is yielding in a non-elastic manner, or is about to yield in that way, if the sudden motions at earthquake centers are examples of such yielding, and if such stress-differences are due to the weight of the continents, or to other causes which act for geological ages with but little change, then we would find that earthquakes are more frequent at times when stresses due to other than these secular causes are greatest, and less frequent when the temporary stresses are least. According to the conception I have put before you, the earth is like a revolver with a hair-trigger. Just as a slight touch on the hair-trigger will discharge the revolver, so slightly unusual stresses in the earth should tend to produce earthquakes. This is apparently the fact. Omori, the Japanese earthquake expert, states that several such relations exist.* At times of high barometric pressure earthquakes of land origin are unusually numerous. Earthquakes are more frequent when the earth and moon are in certain relative positions than at other times, the unusual stresses being produced by the weight of the water concerned in tidal movements. More earthquakes occur in years when the range of variation of latitude is great than in years when the range is small, and Omori states that "all of the destructive earthquakes of recent years in Japan occurred exactly or very nearly when the latitude (at Tokyo) was at a maximum or minimum." The variation of the pole of the earth from its mean value—that is, the variation of the pole of the earth from its mean position—causes small unusual stresses in the earth.

Such relations of earthquakes to other phenomena indicate that the earth is now a failing structure.

It is important for various reasons to know whether the earth is a failing structure, and to what extent it is failing.

Curiously enough, in so far as our personal safety is concerned, the weaker the structure the safer we are. On a very weak earth continuously failing the changes in elevation are so slow that we have plenty of time, as a rule, to move back when the sea encroaches upon the land, and we are seldom shaken so severely by earthquakes as to disturb our comfort. If the earth were stronger the stresses would accumulate for a longer time and to a greater intensity before failure took place; but when failure took place it would be much more apt to bring disaster, by violent shocks and large changes of elevation; therefore the more firmly you are convinced that the earth is so weak as to be failing continuously, the safer you should feel.

It is important to know whether the earth is a failing structure or not, because such knowledge is necessary to a true understanding of many of the phenomena observed upon the earth. For example, it is a standard idea of the text-books, and indeed of many of the specialists in earth sciences, that the flattening of the earth at the poles, its ellipticity, indicates that it was formerly a liquid earth, or is now a liquid earth with a thin crust. If the solid earth is a failing structure in the sense and to the extent that I believe it to be, said standard idea is nonsense.

To those who are endeavoring to make progress in the study of the earth, it is especially important to know the true answer to the question, "Is the earth a failing structure?"

If the answer is "No"; if the earth is, in the main, a competent elastic structure, subject only to minor and local failure, then future progress will be made largely by the elasticians, by those who study the earth as an elastic structure, as did Darwin, for example, in the investigation frequently referred to to-night.

On the other hand, if the true answer is "Yes"; if the earth as a whole is a failing structure, failing frequently or continuously, failing in many parts; if failure is the rule rather than the exception, then future progress in studying the earth is reasonably certain to be made mainly by investigating the manner of failure. These investigations cannot be effectively made by mathematics applied to the laws of elasticity. The elasticians may furnish rough guides, may indicate limits approached but not reached; but the real progress will be made by those who study the non-elastic behavior of the materials composing the earth; by those who study the behavior of the material at the regions of failure; who study its mode of fracture and of flow as it fails; who study the relations between stresses and microscopic structure; between pressure and density; between stresses and chemical condition; between stresses and solution and redeposition; between pressure and the change of state, as between the gaseous, liquid, and solid conditions; between possible stresses in the material and its temperature; between stresses and the growth of crystals.

* F. W. McNair: "Some Problems Connected with Deep Mining in the Lake Superior Copper District." Science, January 4, 1907, pp. 13-18.

* Publications of the Astronomical Society of the Pacific, vol. xviii., No. 109, August 10, 1906, pp. 235-241.

ELECTRIC CULTURE OF PLANTS.*

AT a recent meeting of the Royal Botanic Society, in London, Mr. B. H. Thwaite read a paper describing the new experimental installation which he has carried out at the Royal Botanic Gardens, Regent's Park. The author divided the early workers on this subject into those who utilized the effects of the arc light on the leaves of plants, and those who applied electrostatic stimuli to the plant and to the roots and stalks, in association with solar light; he then briefly summarized the results of their investigations, and explained the function of chlorophyl in the transformation of inorganic matter into organic products under the influence of light of suitable quality.

While it may be broadly suggested in the direction of restoring minerals back from their organic state or association to their mineral state, solar electric energy appears to be directed to the conversion of minerals into constituent elements, making up organic compounds necessary for the generation or creation of organic (animal and vegetable) activity summarized by the expression Life.

If a near imitation of natural forces is to be secured for the artificial cultivation of plants and independently of the sun or weather, the following agents must be assembled and harnessed for the common object: (*a*) An ample supply of violet or chemically active rays projected from powerful arc lights. (*b*) A supply of electrostatic current for atmospheric and root electrification. (*c*) The plant environment of an atmosphere containing moisture and CO_2 in the proportions common to the most fertile countries, and at temperatures within the limits of 70 deg. F. and 80 deg. F. (*d*) An ideal fertilizing agent. (*e*) An ample supply of water for the roots.

The system of electric culture about to be put to a practical test is designed to produce the condition specified, on a sufficiently large scale. The necessary heat and actinic light, as well as the carbon dioxide, moisture and nitrogen fertilizer in the form of ammonia sulphate, are to be derived from coal; "on the perfection of the combustion of the coal or fuel used depends the entire economy of the system," and this perfection can only be secured by converting the carbon into a gaseous condition.

These conditions are fulfilled by the employment of a suction gas producer and gas engine, whereby perfect combustion is attained simultaneously with the development of power, which is converted into electrical energy. The heat absorbed by the cooling water in the cylinder jacket is utilized for the purpose of heating the air in the glass house by means of circulating pipes, and the heat carried off in the exhaust gases is similarly employed by leading them, after purification, through earthenware junction pipes into the glass house, with outlets at suitable points, so that at the same time, carbon dioxide, water vapor, oxygen, and nitrogen are supplied in a heated condition to the plants, with suitable regulating devices at the points of outlet or discharge.

The author divides the heat energy of the coal as follows: 30 per cent to power production, 30 per cent to jacket water, and 30 per cent to waste gases for heating purposes, the balance of 10 per cent being absorbed in generating the gas and in dissociating the water introduced into the producer into hydrogen and oxygen, which afterward recombine and pass with the

* Abstracted from the Electrical Review.

exhaust gases into the glass house as moisture. The gases are desulphurized, both before and after combustion, with bog-iron ore. The electrical energy generated is used for feeding the arc lights. An electrostatic machine driven from the gas engine shaft supplies energy which is discharged by points located along the plants, the object being the electrification, not only of the air of the glass house, but of the plants and their roots as well.

The power and heat developed and the proportion of moisture are easily controlled. The arc lights are equipped with special reflector hoods, confining the beam of light within narrow limits of concentration; the open end of the hood is closed in with a water screen, to secure as near an imitation of natural solar effect as possible, and to limit the effect of the ultra-red rays. The water can be colored if desired. The hood is provided with a chimney to carry off the nitrous oxides that may be produced. The arc lights are constantly and almost imperceptibly moved to and fro along the entire length of the glass house by an electrical traveler.

The installation will permit a wide range of experiments to be made, with a view to determining the conditions to secure the maximum degree of acceleration of plant growth with the most perfect quality and augmentation of weight of the products. The power of producing fruit at any period of the year was successfully attained by Sir William Siemens with a comparatively primitive installation, and the triple combination of water-screened arc light, electrostatic stimulus and highly fertilizing atmosphere will doubtless secure still better results.

THE SAMPSON GAS-ELECTRIC ROAD TRAIN.

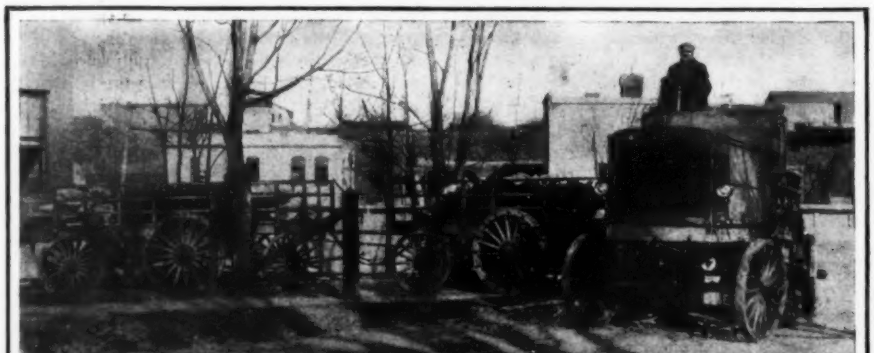
A NOVELTY IN TRANSPORTATION ENGINEERING.

BY HARRY W. PERRY.*

The Sampson Motor Road Train, which was the one great novelty at the recent American automobile show in Madison Square Garden, New York, occupies a unique position in transportation engineering. It combines features of motor-car construction with engineering practice that has been found most successful in subway and elevated railroading. Although evidently designed after ideas that are embodied in the Renard train, which has been demonstrated successfully under all sorts of conditions in several parts of Europe during the last three years, the American train differs from the former in several important particulars, the most notable being the form of power and transmission. This is electricity, adopted on account of its flexibility, which is considered a prime requisite by the designers.

In a train of three or more vehicles intended to transport twenty tons of freight, perhaps over mountain grades and sandy desert roads in the mining districts, the need of ample traction was recognized, and it was foreseen that sufficient load could not be placed upon the tractor to furnish traction enough through its pair of drive wheels alone to haul two or more loaded trailers. Each car of the train has therefore been provided with its own drive wheels, which are driven by power developed in the power plant carried by the tractor. Thus every car is self-propelled, just as every other car in an elevated or underground railroad train is a "motor car"; and the entire train is controlled by a single motorman in the first car. But the motor road train has no third rail or trolley wire to depend upon, so each car must derive its power from the tractor. In the Renard train this is accomplished by mechanical means, the drive wheels of the whole train being connected by bevel gears and universally-jointed driving shafts with the transmission gear of the head or tractor machine.

The source of power in the Sampson train is a 40-horse-power, four-cylinder, vertical, water-cooled gasoline engine, but instead of transmitting the power through many angles, some of which are constantly changing, by positive mechanical means, perfect flexibility is obtained by converting the power into electric current in the tractor and transmitting this through heavily-insulated cables to the motors of each trailer. The engine is coupled by a Morse silent chain to the armature shaft of a large generator placed directly in front of the engine behind the radiator. The voltage is arranged to be varied through a range which insures that the full current capacity of all the motors is within the capacity of the engine. A rotary switch controls the current by the series-parallel system, and is interlocked with the starting rheostat, so as to make it impossible for the operator to damage the apparatus. Switches are provided, so that the train can be hauled by the motors of the tractor alone, or one or more of the trailers can be operated independently while the tractor is standing still. The power plant, including the radiator, is mounted on a sub-frame that is suspended from the main frame by springs, to relieve it from twisting strains and prevent damage from jolting due to the use of steel tires on the wheels.



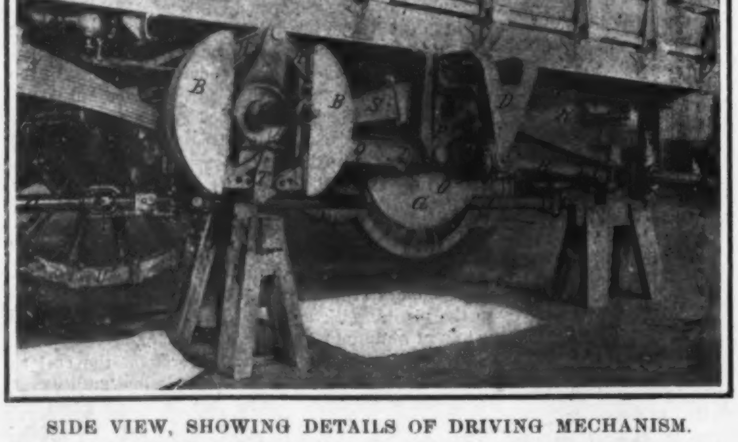
THE TRACTOR AND TWO TRAILERS MAKING AN EXTREMELY SHARP TURN.

The front and rear pairs of wheels of the tractor are shown turned in opposite directions.

Each car has six wheels, the middle pair being drivers and carrying a predetermined proportion of the weight. They are 54 inches in diameter, and have steel tires of a width to suit conditions. Two independent electric motors, spring suspended and especially designed for rough usage and neglect, drive these wheels, being back geared through gears that run in an oil bath to sprocket jackshafts from which the final drive is by 1¾-inch pitch chains. As each drive wheel is thus independently driven and is free to rotate at a different speed from the others, it has been possible to eliminate all differential gearing; and since transmission is electrical with regulation by controller, the construction is further simplified by avoiding the use of sliding-gear change-speed mechanism and jointed drive shafts.

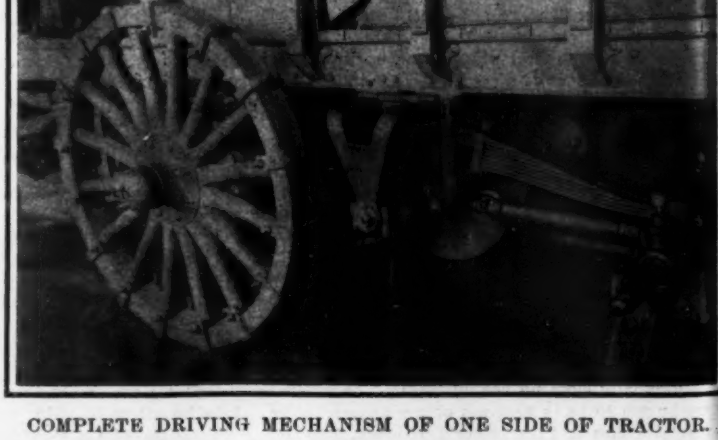
A most interesting and important feature of the Sampson train, not always found in tractor-drawn trains, is the interconnected steering, whereby the wheels of the trailers are caused to follow almost exactly in the tracks of the tractor. Any corner or turn that can be negotiated by an automobile of six-foot wheel base can be made by the entire train. One of the accompanying photographs shows what a remarkably short turn can be made by the train, which is shown almost doubling on itself. In a demonstration in New York, before a few interested persons, when the train was driven from Madison Square Garden to the freight yards by its own motors, the tractor turned a corner in a narrow street with its wheels within six inches of the curb, and the wheels of the last car did not come more than two inches nearer the curb at the same point.

This result is obtained by utilizing both the front and rear pairs of wheels of each car as steering wheels,



SIDE VIEW, SHOWING DETAILS OF DRIVING MECHANISM.

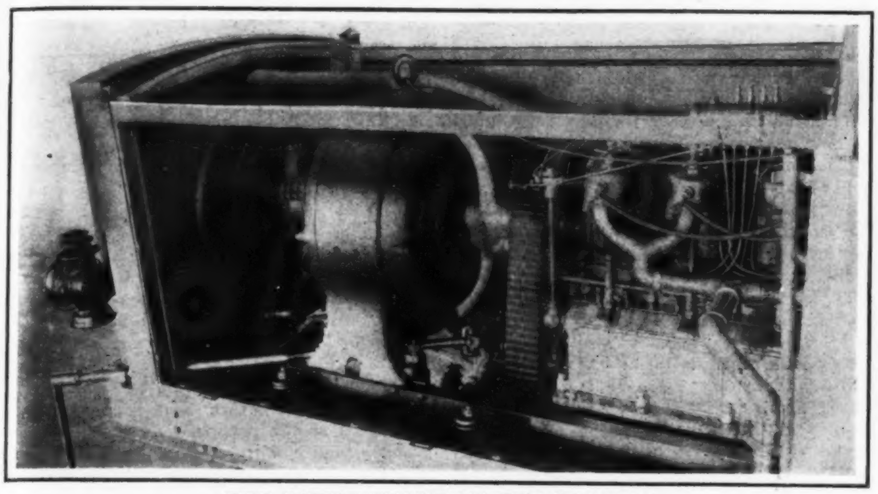
B, B. Brake shoes of expanding brake. *C, C.* Connecting rods of steering gear of front and rear wheels. *D.* Bracket. *G.* Gear case inclosing spur driving gears. *H, H.* Pivot links of brake shoes. *I.* Chain adjuster. *K.* Buffer springs on steering drawbar connection. *O.* Driving sprocket. *P.* Spring pedestal. *Q.* Center axle radius and brake torque rod. *R.* Steering axle radius rod. *S, S.* Springs. *T.* Operating cam for forcing apart brake shoes. *U.* Universal joints in steering connecting rods. *V.* Spring pivot bolt in *P.* *W.* Wire conduit.



COMPLETE DRIVING MECHANISM OF ONE SIDE OF TRACTOR.

The electric motor is seen beneath the body at the right. The incased driving gears on the motor shaft and the short jack shaft are seen at the center, while the driving chain extends from the jack shaft sprocket to the sprocket on the brake drum, which is bolted to the wheel and which contains a powerful hand-operated, expanding-ring brake. The straps fastened over the tire of the wheel aid in getting a grip upon slippery or muddy roads.

and connecting the tongue of one car to the car ahead. The front and rear pairs of wheels are cross-connected underneath the vehicle by connecting rods, the wheels being mounted on steering knuckles as in automobile practice. The connecting rods are provided with universal joints and supported at the middle, the joints relieving the rods of strains due to the changing positions of the front and rear axles as the car moves over uneven ground. The driver, sitting on the tractor, controls the direction by a hand wheel and irreversible gear connected with the front pair of steering knuckles of the tractor. By means of the cross-connecting rods underneath, the rear wheels are simultaneously turned in the opposite direction to precisely the same angle, thereby giving the car a pivotal motion on the middle pair of driving wheels. This carries the rear end to the outside of the circle, so that the rear wheels, instead of cutting inside of the track of the front ones, follow the same path.



THE POWER PLANT ON THE TRACTOR.

A dynamo in front is chain-driven from a 40-horse-power, 4-cylinder engine.

The method of connecting the steering of the trailers with that of the tractor will be understood by reference to the photograph of the front end of the tractor, it being kept in mind that all of the cars are "double ended," that is, are alike in all respects at both ends, so far as connecting them together is concerned. It will be noticed that a yoke bolted to the axle at its center point is also fastened to the tie rod that connects the steering knuckle arms. In the slots seen at the two ends of this yoke may be bolted a forked steel tongue. Assuming that we are now considering the front end of a trailer instead of the tractor, the free end of this tongue, which has an eye, is connected with the rear end of the tractor. This connection is made, after removing a cotter pin and washer, by slipping the eye up onto the vertical eyebolt, which is seen just below the drawbar link pin. The photograph shows an ingenious means for cushioning violent side thrusts of the tongue. The eyebolt is clamped to a horizontal rod that is free to slide in the metal frame bolted to the under side of the car, and the bolt to which the tongue is attached projects down through a slot in said frame sufficiently long to allow considerable lateral motion. This motion is cushioned, however, by helical compression springs (*K* in the side view showing details) surrounding the sliding rod and confined by the head of the eyebolt at the center and the ends of the cage or frame at their outer ends.

It will readily be understood that owing to the opposite angles the steering wheels of the tractor or leading car assume when making a short turn, the rear end swings out as the front end swings in, exactly as when a long street car turns a short corner and the front and rear trucks assume opposite angles. The outward swing carries the front end of the tongue of the trailer in the same direction it had been moving in before up to a certain point, when it is suddenly deflected in the new direction. As the tongue moves, it changes the angles of the four steering wheels of the trailer. Thus the front of the first trailer begins to make the turn at practically the same point that the tractor did, while the rear end swings outward, continuing the second trailer in the original direction. With this construction the whole train, measuring 60 feet in length, can be turned in a circle having a radius of 20 feet, measured outside the hubs. The steering is as easy as that of a five-ton truck, and the control is so simple that one man can operate the entire train with ease.

Drawbars are used between the cars, but their principal function is to preserve the distance between them and equalize traction. The torque is so evenly distributed throughout the train, however, that it has been found possible to go between the cars and pull out any one of the drawbar pins while the train was climbing an 11 per cent grade under load.

Braking is effected electrically through the motors under ordinary conditions and is controlled by a point on the controller which gives an amount of braking power equal to the capacity of the motors. This system operates smoothly and is easy to handle. But for emergency purposes and for service in very hilly country, each of the driving wheels is fitted with powerful expanding brakes operating inside the sprocket drums. Those on the tractor are set by means of a hand wheel just below the steering wheel, while those on each following car are operated by a wheel attached to the side of the frame and manipulated by an assistant on each trailer. With the exception of these brakes, the entire control of the train is in the hands of the driver, who rides on the tractor.

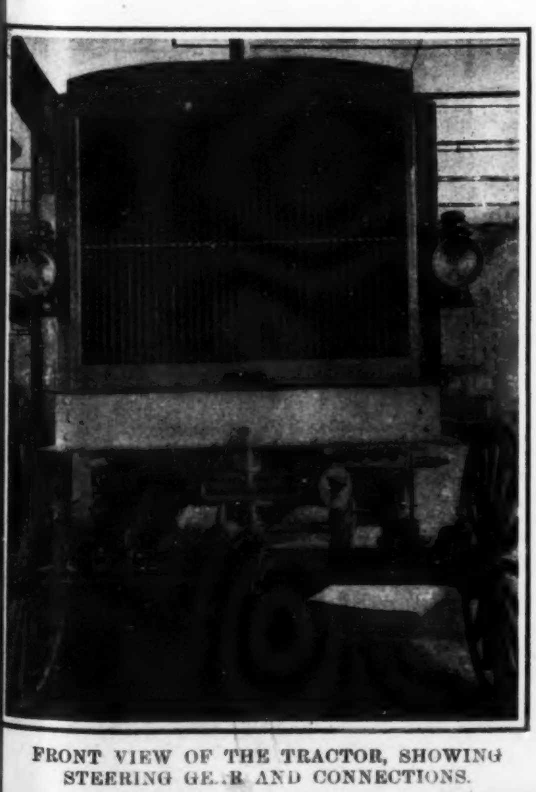
To facilitate making up the train and moving about in small yards, the units are made double-ended, and can be connected up and run either end foremost with equal facility. This is the case with the tractor as well as with the other cars. Sockets are provided at each end of the frames, into which plugs on the ends of the electric cables can be pushed to make connection. By using long cables, the units can be moved freely at some distance from the tractor. Although all wheels are shod with steel tires, which give plenty of traction on ordinary roads, wood or rubber-base tired wheels can be used as drivers where the conditions require them.

Since returning from the show and completing details of construction necessarily left undone before, the train has been under road tests, and grades of 11 per cent have been taken under load. The flexibility of the electric drive and the complete reversibility of each car has, as was anticipated in the design, proven to be not only of great advantage, but an absolute necessity in a train of this kind.

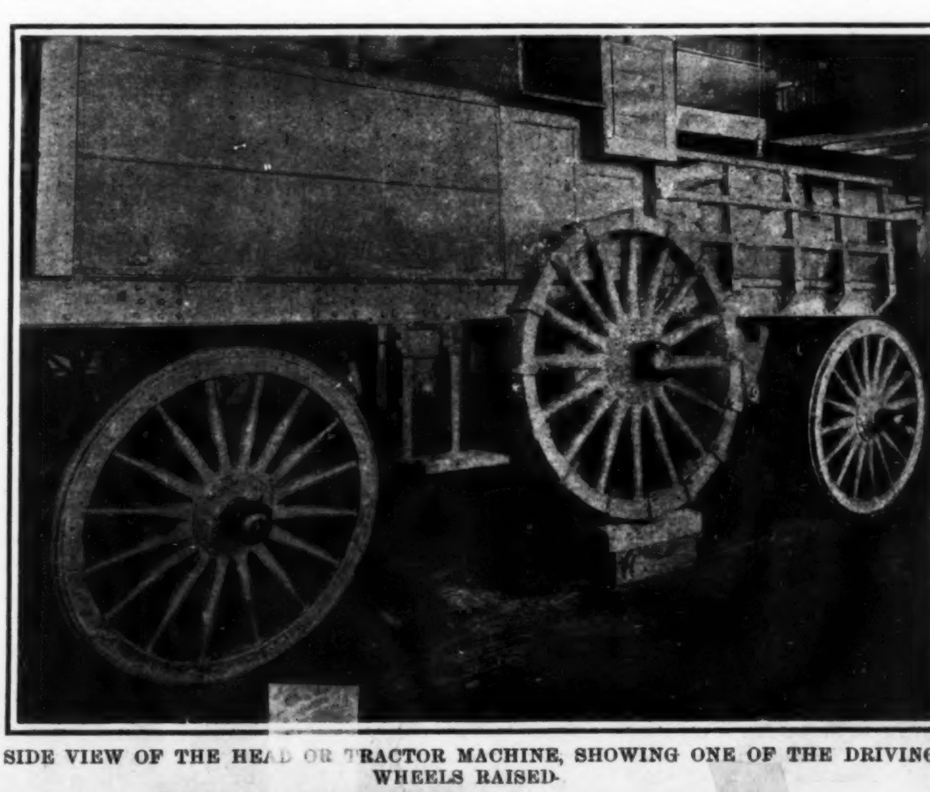
It was lately necessary to load the train at the end of a long, crooked alley, which had a gate rail preventing the tractor from entering, and in which there was no place to turn. The tractor was left in the street and, with power supplied through long cables provided for the purpose, the cars were run into the alley, steered by hand, and after being loaded they were run out again in the same manner, with steering tongues reversed. In the same way, any number of cars could be loaded at different points of a yard, and when ready placed in line behind the tractor by their own motors—an advantage not obtained by any mechanical drive.

The tractor has a carrying capacity of from two to three tons in addition to the power plant, and each trailer can carry six to eight tons. The dimensions of the platform are 17 feet by 4 feet 2 inches. The bodies are carried on four semi-elliptic springs of extra length, which are pivoted and guided in pedestals, and have the functions of equalizing beams to distribute the load uniformly on the three axles, no matter how rough and uneven the road, and of maintaining the axles in correct crosswise position relative to the body. Distance rods hold the axles against displacement fore and aft, and the ends of the springs merely rest in pockets on the axles, thus contributing to flexibility. The construction embodies no untried ideas, however, and standard materials have been used, with a view to easy repair and replacement in remote places. A speed of 6 miles an hour can be attained with a load of twenty tons on level, hard macadam roads, and 2 miles on a macadam 10 per cent grade. On level dirt roads the speed is 5 miles an hour.

A train of this kind will no doubt make possible the handling of large loads economically.



FRONT VIEW OF THE TRACTOR, SHOWING STEERING GEAR AND CONNECTIONS.



SIDE VIEW OF THE HEAD OR TRACTOR MACHINE, SHOWING ONE OF THE DRIVING WHEELS RAISED.

THE ALBUQUERQUE GEOLOGICAL MEETING

A RÉSUMÉ OF THE PROCEEDINGS.

BY EDMUND OTIS HOVEY

ON December 30 and 31, 1907, the Geological Society of America met at the University of New Mexico, Albuquerque, for its twentieth annual meeting. About thirty members of the society were present, all but one of whom had traveled from half a day to four days to attend the meeting. The exception was Prof. W. G. Tight, president of the university, who was responsible for getting the society to meet in Albuquerque, and by reason of whose admirable arrangements the meeting was one of the most satisfactory the society has ever held. The presiding officers were: President, Charles R. Van Hise, of the University of Wisconsin, Madison, Wis.; first vice-president, Mr. J. S. Diller, of the United States Geological Survey, Washington, D. C.; second vice-president, Prof. A. P. Coleman, of Toronto University, Toronto, Canada.

The report of the secretary, Dr. E. O. Hovey, of the American Museum of Natural History, New York city, showed 294 names on the list of members. The fourteen members elected at the New York meeting in December, 1906, qualified during the year, but two were lost by death and one by resignation, leaving a net gain of eleven over the latest printed list.

The two members who died were Prof. James Safford and Angelo Heilprin. Prof. Safford was a man eighty-five years of age, a pioneer of geology in America, who spent most of his active scientific life in Tennessee. Prof. Heilprin was only fifty-four years old, and would probably have had many additional years to live and work, had not the hardships of exploration in the tropics brought on fatal disease. An intrepid explorer in many zones and climates, he was a fascinating lecturer to students and the general public, and his loss will be deeply felt by many.

Fifty-two papers were listed in the programme, but absence of the authors cut the number actually presented in whole or in part down to twenty. Prof. F. R. Van Horn, of Cleveland, Ohio, read a paper "On the Occurrence of Proustite and Argentite at the California Mine near Montezuma, Colorado," in which he stated that these enormously rich silver ores occurred in seams sometimes two inches thick along the middle of a banded vein of argentiferous galena associated with sphalerite. The next paper was by Dr. A. C. Lane, State Geologist of Michigan, "On the 'Field Assay' of Mine Waters." The author showed the need there is of supplementing by tests and analyses of mine waters the theory of ore deposition by circulating underground waters, and exhibited a pocket total reflectometer, which he had devised for the purpose of making rough tests in mines.

Prof. A. P. Coleman, of Toronto, Canada, discussed "Glacial Periods and Their Bearing on Geological Theories," saying that four well-defined glacial periods were known in geological history, occurring in the Pleistocene, and Permo-Carboniferous, the Lower Cambrian, and the Lower Huronian, final proofs of the last-named glacial period having been obtained only recently. The author stated that the wide distribution of glacial deposits in at least three of these periods proves that refrigeration was general and included both hemispheres, and that there was evidence of important interglacial periods in three of the ice ages. He concluded the paper by pointing out the importance of these facts as bearing on the origin and early history of the earth and on the factors which cause variations of climate. The active discussion that followed the reading of this paper showed that the evidence for the existence of a glacial period in Lower Huronian time was not considered conclusive by all the geologists present, since surfaces which were glacially striated during that period had not yet been found.

"The Chief Features of the Stratigraphy and Structure of Mount Diablo, California," was the title of a paper by Prof. George D. Louderback, of Berkeley, Cal., in which the following considerations were brought forward: Mount Diablo is a distinctive feature of the central Coast ranges because it rises from low valleys on practically all sides, and is not merely a more prominent peak of a continuous range. It shows a remarkably complete stratigraphic series of the characteristic Coast Range formations. Structurally, it is an overturned and overthrust anticline of very late origin. There is also evidence of an earlier structural form. The geology of Mount Diablo may be taken as showing a stratigraphic succession and an orogenic history characteristic of the coast ranges from the Klamath Mountains to the Tehachapi.

Prof. H. P. Cushing, of Cleveland, Ohio, then read a paper on "The Lower Portion of the Paleozoic Section in Northwestern New York," which may be abstracted as follows: In Jefferson County, N. Y., in the district between Watertown and Alexandria Bay, the Potsdam sandstone and the Lowville, Black River, and Trenton limestones are present in quite normal expression. Between the Potsdam and the Lowville are two additional formations. The lower of these passes into the Potsdam by gradation, and is lithologically like similar "passage beds" elsewhere in northern New York. It consists of alternating sands and sandy dolomites, varies in thickness from 15 to 75 feet, and has an erosion unconformity at its summit. It is overlain by an impure limestone formation, which overlaps on the district from west to east, reaches a thickness of 125 feet, and holds a fauna not hitherto noted in New York, which is tentatively correlated by Dr. E. O. Ulrich with that of the upper Stones River formation of Southern Pennsylvania. It has close relationship to the Lowville formation above. The Chazy formation is absent, as is also the entire Beekmantown. The physical break between the two formations is the most prominent one as yet noted in the New York Lower Silurian. The section is compared with those east and south of the Adirondacks, and the additional light which it throws on the physical oscillations of the region is considered.

The afternoon session of the first day's meeting began with the reading of the annual address by the retiring president, President Charles R. Van Hise of the University of Wisconsin, which discussed "The Problem of the Pre-Cambrian." President Van Hise has devoted many years to the study of the problems presented by the Pre-Cambrian rocks, which are the most puzzling of all those within the range of geology. The nature of the paper precludes any effort at condensing it for these columns.

The next paper read was upon "The Relation of the Equus Beds of Kansas to Reversed Mississippi Drainage," by President W. G. Tight of the University of New Mexico. The Equus beds are deposits of early Pleistocene age, and the author considers that the facts observed in the field show that during their deposition the northern portion of the Mississippi valley drained northward.

In a paper upon "The Grenville-Hastings Unconformity," Messrs. Willet G. Miller and Cyril W. Knight of the Bureau of Mines, Toronto, gave the results of recent studies bearing upon some of the questions discussed in the presidential address. The authors said in part: The crystalline limestone and associated Pre-Cambrian sedimentary rocks of southeastern Ontario, and the adjacent parts of the Province of Quebec, to which Logan and his colleagues long ago gave the names of Grenville and Hastings series, have never been satisfactorily classified as regards their age. Recent work by the authors has shown that much at least of that which has been called the Hastings series, consisting of limestones, conglomerates, and other fragmental rocks, is much younger than, and forms a well-defined unconformable series with, the typical crystalline limestones and associated fragmental rocks of what has been called the Grenville series proper. The view that the Grenville and Hastings constitute one series, the former being a more highly altered phase of the latter, is no longer tenable. The Keewatin series of the Lake Superior region is represented in southeastern Ontario by ancient rocks of like character. The Grenville limestones have been deposited on the surface of the Keewatin. The authors class the Grenville limestone, as regards age, with the Keewatin iron formation of Lake Superior, which it has not been found possible in that region to separate from the greenstones. The Pre-Cambrian conglomerate and associated sedimentary rocks overlying, unconformably, the Grenville limestone, are classed as Huronian. The conglomerate contains not only ordinary fragments of the Grenville limestone, but "eozoon"-like bowlders as well, thus showing that the limestone is much older than the conglomerate. Moreover, the "pebbles of cherty and ferruginous rocks resembling those found in the iron ranges of the Lake Superior" in the conglomerate of eastern Ontario are found to have been derived from layers or bands of this material in the Grenville limestone.

Dr. Alfred C. Lane, State Geologist of Michigan, followed with the announcement of the determination of a new Silurian fauna in Michigan which had been made by Prof. W. H. Sherzer of Ypsilanti, Mich., and Prof. A. W. Grabau of New York city. The fauna occurs in a limestone which usually consists of a more or less condensed coral and stromatopora reef, to which the name of the Anderdon limestone has been given. The fauna is of a transition nature between Silurian and Devonian types. Dr. Lane then proceeded to a discussion of the "Nomenclature and Subdivisions of the Upper Siluric Strata of Michigan, Ohio, and Western New York," based upon investigations made largely for the Michigan Survey.

The concluding paper of the afternoon was on "The Structure and Stratigraphy of the Ouachita Ordovician Area, Arkansas," by Prof. A. H. Purdue of Fayetteville, Ark.

The second day's morning session opened with the consideration of the report of the committee favoring the establishment in territory belonging to the United States, Canada, and Mexico of a series of stations for the study of volcanic and seismic phenomena. This report was adopted, and then an overture was received looking toward the formation of a general committee on nomenclature, which should represent the several geological survey organizations of the United States, Canada, and Mexico, and also geologists not in connection with any official survey. At the end of the afternoon session this question was taken up again, thoroughly discussed, and the formation of such a committee recommended.

The first scientific paper of the day was by Prof. John E. Wolff of Harvard University, in which he presented the results obtained by Dr. George R. Mansfield of Harvard and himself in a study of the Crazy Mountains, Montana, made last summer. The Crazy Mountains are a most interesting district on account of their geology, petrography, and physiography, including scenery. During the Glacial Period they were the seat of local glaciation. All the higher valleys contained small glaciers, as is indicated by the numerous cirques. Some of the glaciers on the south and east slopes attained considerable size, notably those of Big Timber and Sweetgrass-American Fork canyons, which must have had lengths of approximately 15 to 18 miles, as shown by the extent of morainic deposits. Glaciation is not yet extinct. A tiny glacier was seen at the head of Big Timber and another in Sweetgrass canyon, and a third is reported by Assistant Forester Wilson at the head of Rock Creek. Glacial topography predominates throughout the southern section of the mountains and occurs locally in the southern section. Striæ and truncated valley-spurs along the sides of the canyons show that the ice must have been 500 to 800 feet thick. The glaciation succeeded a long erosion period, in which the region had reached an early stage of peneplanation. It continued long enough to form broad, deep troughs in the weaker rocks, and to produce much of the sharp *arête* topography so characteristic of the southern section of the mountains. Later stream erosion has incised the glacial deposits, and in some cases the old troughs.

A paper on "The Sandia Mountains" was then read by President W. G. Tight, preparatory to an excursion planned for the day after the meetings.

In a paper on "The Topaz-Bearing Rhyolite of the Thomas Mountains, Utah," Prof. Horace B. Patton of the Colorado School of Mines at Golden, Colo., brought forward some interesting points with reference to the familiar topazes from Utah. Extensive rhyolite flows occur in the Thomas Mountains of Juab County, Utah, associated with somewhat more basic eruptives. The rhyolite has been profoundly affected by mineralizing vapors that have removed all trace of dark-colored constituents and have caused the development of a surprising number of topaz crystals, with occasional garnet and specular hematite. The topaz crystals occur (1) in lithophysal cavities associated with quartz, and are then mostly clear crystals having a handsome brownish yellow wine-color that quickly disappears on exposure to direct sunlight; (2) imbedded in the solid rhyolite and having frayed-out ends but fairly well-developed prismatic faces. These are brownish in color before exposure to light, but are rendered opaque by numerous inclosures of quartz crystals. Similar crystals, but perfectly developed and with double terminations, were found imbedded in fragments of a very fine-grained rhyolite tuff, the fragments being themselves inclosed in rhyolite.

Mr. J. S. Diller of the U. S. Geological Survey then read a paper on "The Strata Containing the Jurassic Flora of Oregon," in which he said in part: The Jurassic flora of Oregon has been described and designated by Profs. Lester F. Ward and William M. Fontaine in the U. S. Geological Survey, Twentieth Annual Report, pt. 2, p. 217, and Monograph 48. The localities of its occurrence have been greatly extended among the Klamath Mountains of California, and several distinct faunas have been found at different places in the same strata. On the one hand it is clearly

associated with a characteristic Knoxville fauna, and on the other with a fauna that may be older than the Mariposa. In a second paper, Mr. Diller described the local silicification of the Knoxville beds referred to in his first paper.

In view of the excursion planned for visiting the Grand Canyon of the Colorado after the adjournment of the meeting, the following paper in the absence of its author was read by Dr. C. W. Hayes: "Wind Erosion in the Plateau Country," by Dr. Whitman Cross of the U. S. Geological Survey. Dr. Cross laid stress upon the agency of the wind in eroding certain beds, a feature which has till recently been overlooked in discussing geologic activity in the region.

The next paper, which was by Prof. G. D. Louderback and Mr. W. C. Blasdale of the State University of California, pertained to the gem mineral benitoite, which was discovered last year in California. Benitoite is a beautiful deep sapphire-blue mineral with a high index of refraction that gives great brilliancy to gems cut from it. Unfortunately, it is too soft for hard usage, its hardness being between 5¼ and 6½ of the usual scale. In chemical composition it is a titano-silicate of barium with the formula $BaTiSi_3O_9$.

In a paper entitled "Shoreline Studies on Lakes Ontario and Erie," Prof. Alfred W. G. Wilson of McGill University, Montreal, said in part: The initial shore lines of these lakes were very complex because of the complex character of the basins in which they lie. The process by which the shore lines have been brought to their present stage of development is almost wholly due to the action of waves and the currents generated by them. Tides and other currents strong enough to be effective agents in transportation do not exist in the Great Lakes. The materials found on the shores are almost wholly of glacial origin. They are being distributed along the shores by the shore processes, and there is evidence of the existence of two nodal points on each lake, one on the north shore, and one on the south. East of these points the resultant general movement of shore débris is east, west of these points it is west. Locally there may be at any specified time movements in either direction, according to the direction of the wind and waves at that time.

After the end of the reading of formal papers, Dr. C. W. Hayes informally exhibited a set of photographs of the fossil woods of Arizona, together with notes on them by Dr. David White, palæobotanist to the United States Geological Survey. Then President W. G. Tight exhibited and described a series of stereopticon slides illustrating glacial and other phenomena among the High Andes of Bolivia, and the scientific programme was declared finished.

After passing suitable resolutions of thanks to the citizens and the Commercial Club of the city of Albuquerque, to the authorities of the University of New Mexico, and particularly to President Tight for the hospitality enjoyed and the arrangements made for the meeting, the society adjourned. New Year's Day was spent in a geological excursion given by the university and the Commercial Club to the Sandia Mountains east of the city, and that night most of the members in attendance left on a special car to visit the Petrified Forest and the Grand Canyon of the Colorado. A few of the members also visited the famous Coon Butte or Meteor Crater in Arizona before they returned to their homes.

Four new fellows were elected to the Society in connection with this meeting, namely: Major Clarence Edward Dutton, U. S. A. (retired), Englewood, N. J.; Prof. D. P. Penhallow, McGill University, Montreal, Canada; Dr. Percy Edward Raymond, Carnegie Museum, Pittsburg, Pa.; Prof. Thomas Edmund Savage, University of Illinois, Urbana, Ill.

The following officers were elected for the year 1908: President, Samuel Calvin, Iowa City, Iowa; first vice-president, George F. Becker, Washington, D. C.; second vice-president, A. C. Lawson, Berkeley, Cal.; secretary, Edmund Otis Hovey, New York city; treasurer, William Bullock Clark, Baltimore, Md.; editor, J. Stanley-Brown, Cold Spring Harbor, N. Y.; librarian, H. P. Cushing, Cleveland, Ohio.

ASTRONOMY WITH A THREE-INCH TELESCOPE.*

WHAT CAN BE DONE WITH A SMALL INSTRUMENT.

BY WENDEL L. PAUL.

It is the object of the present article to point out, while letting the mathematics of the subject entirely alone, the pleasures which may be derived through the use of a three-inch telescope, intelligently handled. An instrument of this size has much to commend it. It is of an aperture almost invariably found among amateurs, and gives perhaps better results for its aperture and expense than slightly larger or smaller instruments.

Once proficient in its use, an enterprising observer has before him a mine whose treasure he can scarcely hope to exhaust, even in the leisure evenings of many years. Few professionals who have not themselves begun with small instruments seem to realize the number of objects deemed hardly worth attention with larger apertures, which can not only be picked up but well seen with a three-inch glass. Success in this case depends not so much on being able to see a thing as on knowing how to see it; a measure which can result only from experience and practice. First experiences with a telescope are generally somewhat disappointing, but a little patience and perseverance quickly rectifies the matter.

Telescopes are of two kinds, refracting and reflecting, either of which possesses its own peculiar advantages or disadvantages, but for the amateurs, the former alone is worthy of consideration unless indeed he be of a mind to construct his own glass. Far more can be observed with a refractor than with a reflector of similar aperture; but the latter type presents less difficulty of construction and involves less skilled workmanship than the former. The most common instrument found among amateurs is of the refracting type and has an object glass of three inches diameter. The cost of such a glass varies with the excellence of the make, but an instrument suitable in every respect can be obtained for seventy-five dollars. The usual form of mount is an ordinary garden tripod which is portable and, if steady and well put together, is all that is required. The most important part of the instrument is of course the object glass, and too great care cannot be exercised to get a good one. Generally those sold by the leading opticians are reliable, but the glass should not be accepted until certain of its excellence. A number of eye pieces of various power are a necessary adjunct, as a change of power is often a great relief to the eye. The magnification employed is also dependent on the state of the weather, and the nature of the object. For planetary work a power of two hundred is not too high, under favorable circumstances. In comet sweeping, an eye piece of as low power as twenty-five diameters will be most convenient. The observer must regulate his choice to suit his need.

Probably the first object to which the beginner will turn will be the moon, and no better starting point for his celestial survey could be found. The rugged surface of our satellite presents even in a three-inch glass such a scene of grandeur that one can wonder tirelessly over its rocky fastnesses and towering mountains. When under oblique illumination these stand out in strong relief from the lower plane, casting tremendous shadows upon the surrounding floor. Far out beyond the terminator scattered peaks of great height can be seen coming into view, the sun's rays having already caught their lofty summits before the lower ramparts become illuminated. It is an absorbing spectacle to thus watch a sunrise upon another world, as gradually peak after peak bursts into view crowned with the golden splendor of the rising sun. The ring plains, and crater mountains with their central cones and buttressed ramparts are objects of great interest. Their volcanic origin is apparent at a glance and we everywhere see evidence of the tremendous forces which have been at work upon the surface of our satellite. Observation should be made upon the moon continuously from new until she has again reached that position, and the various formations studied under all angles of illumination. The great plains with their ridges and tiny crater pits and the mysterious whitish streaks which cross the surface will repay many a night's study. But other objects besides the moon await the beginner, and of these let us first consider the next most closely related members of our system, the planets.

Of Mercury we can see very little owing to his proximity to the sun. Even when he has been successfully found it is quite out of the question to expect to make out surface markings. Owing to his orbit being interior to ours the little planet runs through phases similar to the moon and the best we can expect to see of him is a silver crescent in the twilight of evening or morning sky. Venus, the twin of the earth, is a much more interesting object than Mercury, but in her case, too, we are handicapped by her orbit being interior to ours. She too runs through phases similar to the moon and a charming sight she is seen with our lens. Venus is, however, one of the most difficult objects to observe owing to the flood of light in which she is deluged, and the extent of her atmosphere which reflects a great part of the light incident upon her. None but a good glass can show her well and then we must have good seeing. Passing outward from our earth we come next to the planet Mars and in a three-inch telescope we shall find him a much more satisfactory object than either Venus or Mercury. At a favorable opposition dark markings can be made out and the polar caps clearly seen. Beyond Mars, Jupiter, the giant of the solar system, permits of considerable profitable study with a three-inch lens, both on account of his cloud belts and surface marking as well as of his ever-circling satellite system. Here we may observe eclipses of his four attendant moons and watch the progress of their shadows as dark spots across his disk. It was by such methods that Römer first measured the velocity of light.

Saturn is an object of immense interest by reason of the ring which girdles him. This can be seen to great advantage with our lens, and also the dark belts upon the planet's surface similar to Jupiter. His satellites are of less interest, but four of them may be seen under favorable circumstances. Uranus and Neptune are too remote to repay much attention, and indeed they are rather unsatisfactory objects even in larger instruments.

Beyond the orbit of Neptune objects of a very different nature await us. The observation of the double stars, nebulæ, and star clusters constitutes one of the most fascinating branches of astronomy open to us, and in the case of double stars really useful work has been performed with instruments of our aperture. In the case of the double or multiple stars the colors and magnitudes of the components should be carefully noted and the results compared with others. Extremely beautiful contrasts of color will be found among some pairs. The amateur may also test his eyesight and the quality of his lens by attacks upon double stars whose components are just within the separating power of his glass (1.52 sec.). There is a peculiar fascination in this work and when after long observation the smaller companion star suddenly, in a moment of steady seeing, flashes out from alongside its greater primary, an extremely gratifying feeling of triumph ensues.

The study of the nebulæ will give the observer an insight into the nature of these remarkable objects, as numerous examples are within the power of his lens, showing their development from hazy diffuse clouds of incandescent fire-mist into suns or clusters of suns. Among them we see illustrated the various stages through which our own system has passed in its growth.

Still other fields of work are open to the possessor of a three-inch telescope, and fields which offer opportunity of really valuable work being accomplished. These are the continued observation of variable stars and comet sweeping. Many variables are constantly being discovered by such means. In fact many have been found with no more optical aid than the opera glass. Comet sweeping if carried on diligently is very apt to result in success, but here the element of luck is very conspicuous.

To conclude, the owner of a three-inch telescope has before him a field of work both in and without the solar system with which he can occupy his leisure hours for many a night and year, and by which he may gain the intellectual pleasure which only such knowledge can inspire.

* Abstracted from the Yale Scientific Monthly.

C. C. Trowbridge in the Astrophysical Journal says that meteor trains are the luminous clouds formed by meteors which persist long after the incandescent nucleus has disappeared. The average of the heights above the earth's surface of the middle portion of the trains is 54 miles (87 kilometers), the minimum being about 45 miles, and the maximum 65 miles. It would thus appear that in the zone between 50 and 60 miles' altitude there exist the special atmospheric conditions necessary for the production of these phenomena. That the appearance is due to gaseous phosphorescence

is probable (1) because of the rapid lateral expansion of the train, evidently a gas diffusion, amounting to a mean rate of over 100 meters per minute; (2) on account of the great volume contained within the boundary of the train, usually amounting to many cubic miles; (3) because the observed spectrum consists of bright lines. Further, the rate of decay of the glow corresponds to values found in the laboratory for the electrodeless ring discharge in gases. The dual appearance of the trains is ascribed to their tubular nature, giving increased intensity at the two edges in the line of sight.

SCIENCE NOTES.

J. G. Davidson has recently published a paper in Physikalischer Zeitschrift describing some of the actions of ultra-violet light. In it he says that when metal wires have been kept in a region where ionization existed they are accustomed under the action of ultra-violet light to lose a negative charge much more quickly than before. This result is sometimes obscured by changes in the metal itself—as, for example, by oxidation. It is best observed in the case of Pt or Pd, which possess a great power of absorption and are free from corrosion. A piece of Pt held in an ordinary gas flame is very active, and the same result is obtained, though in a less degree, if it is held over the flame when the gases are cold. This activity remains practically constant, while the wire for two to three hours gives off negative electricity under the action of the light, if it has been thoroughly heated in the flame. When the activity finally begins to slacken it falls away practically to nothing in a few minutes. If a wire which has been made active by a flame is kept for a week in dust-free air, its activity does not fall off in intensity, but it can be dispelled if the wire is heated by an electric current in air to a temperature not far above 300 deg. A wire becomes active if it is made to serve as electrode in an electrolytic cell, care being taken to avoid the presence of hydroxide. No activity will exist if oxygen is admitted to the wire, and such activity as the wire formerly possessed will thereby be dissipated. An inactive wire will be made active by heating in air to redness by an electric current. With platinum this activity is permanent, but, on the contrary, metals which oxidize at the temperature employed will be inactive in a few seconds at room temperature. A charged wire attains activity in flame gases no more quickly than an uncharged one. A charged or neutral wire in air which is strongly ionized by Röntgen rays or by radio-tellurium is inactive. The author has made a series of observations on the activity of wires which have been treated in various ways with rising and falling temperature in air at atmospheric pressure. In general it has appeared that those wires whose activity is to be ascribed to an alkali metal or an occluded gas exhibit a more or less distinct minimum at a temperature between 100 deg. and 200 deg. The activity of the less easily oxidized metals does not exhibit this minimum. In all cases the curve rises very quickly when the wire approaches redness.

Excavations recently made at Sousse, on the Mediterranean coast near Tunis, have brought to light some interesting discoveries. They are carried on at present under the direction of Abbé Leynaud. He found extensive catacombs under the existing town, which it will be remembered lies on the site of the ancient Roman town of Hadrumetum. The total length of the catacombs is estimated at nearly one mile. Like the Roman galleries, they are cut in the tufa rock, and their width varies from 6 feet to 2½ feet, while the average height is 8 feet or more. The loculi or recesses for the sarcophagi are found as usual in the sides of the galleries, and there are generally three ranges of these. Each recess is closed usually by three large tiles. In the walls are small niches for containing lamps. The inscriptions in the catacombs are in black upon the tiles or scratched by a point upon the lime. They are short, with only the name and date in most cases, with the customary formula, "*in pace.*" Many of the inscriptions have disappeared and others have suffered from time and cannot be deciphered. The catacombs of Hadrumetum can be compared with those which are found on the coast of Sicily, especially at Syracuse. They have a striking analogy with those of Tropæa in the south of Italy, where the disposition of the tombs is similar. Among the epitaphs is one of a youth of six years, L. Stertinius Martialis. A large slab of white marble contains an inscription of a person named Theodora and it resembles the marble tablet found at Lenta and now placed in the Bardo Museum of Tunis. In the catacombs was found a plaster bust, but it does not properly belong here and most likely came from one of the numerous pagan tombs which Capt. Sabatier's expedition is working. It was probably thrown into the catacombs at an undetermined epoch. The bust is of interest, as it seems to be a mold taken of the face of a middle-aged person after [illegible] are well [illegible]

Gas mantles are generally formed of cotton thread which has been impregnated with oxide of thorium or cerium. By means of a Bunsen burner the thread, first soaked with the salts of these metals, is burned and the salts in becoming calcined are transformed to oxide. Cotton and ramie fibers are about the only ones which are suitable for the purpose. Silk, hemp, and jute cannot be used to advantage here, as they are not well impregnated. In the new process which is brought out in France, the inventors use an artificial thread formed of cellulose which has been treated with copper salts. It is found, however, that when such a thread is treated with a thorium salt solution, then dried and burned in the flame, the deposit of thorium oxide is not a stable form, and the whole crumbles to powder. But they succeed in overcoming this difficulty by transforming the thorium salt into oxide in the cold upon the fiber. In this case the nitrate of thorium is reduced to oxide by means of ammonia, and the oxide which is thus produced will not swell up under the action of heat, but is found to contract in the form of small crystals which are very hard. What is striking is that cotton or ramie fiber cannot be used in the same way as the copper-cellulose in this treatment, and the resulting mantle is not durable. An advantage of the new mantle is that it is not hygroscopic. As regards solidity, the new mantle was found on test to support 2,000 or 3,000 shocks instead of 90 or 100 for the usual kind. The duration is 3,000 hours' burning, and the light is found to be 120 or 130 candle-power. Ammonia is not the only reagent which can be used to form the oxide of thorium precipitate. Benzine and hydroxyl at 60 deg. C. will throw down a pure hydroxide of thorium. Hydroxyl will not bring down cerium from its salts, however, so that in this case we dissolve a great excess of cerium salt in hydroxyl and use the latter to throw down the thorium oxide, when the cerium oxide is drawn down mechanically by the oxide of thorium.

ENGINEERING NOTES.

A railway line to connect India with Ceylon has been projected by Mr. H. W. Perry, district traffic superintendent of the South Indian Railway, and is described in a pamphlet issued by him. The total distance is about 25 miles, of which 7 miles is in the form of islands above tidewater, 4 miles is in shallows less than 3 feet deep, 6½ miles is less than 10 feet deep, 6½ miles is 10 feet to 20 feet deep, and only a mile is over 20 feet deep.

The U. S. consul at Monterey reports that oil fuel is coming into general use among the railroads in Mexico. The Mexican Central Railway is now taking 4,000 barrels of fuel oil daily from the Mexican Petroleum Company, at a cost of about $4,400 daily. The Mexican Central is steadily increasing the number of oil-burning engines in service, and within the next few months the road will be taking much more fuel oil than at present. All new engines purchased by the Mexican Central are equipped for burning oil.

Some idea of the expenditure and efforts made by the farmers in Queensland to mitigate the rabbit pest may be gathered from the fact that in the colony 16,152 miles of close-netted fencing have been erected, the maintenance of which involves an outlay of $700,000 per annum, including the interest on the capital expended for fencing, which represents approximately $4,000,000. To keep this mileage in repair alone costs $400,000 per annum. Despite these precautions, but little headway can be made against the multiplication and ravages of the pest, but this condition of affairs is stated to be mainly the fault of the government, which takes no steps to arrest the fecundity of the animals upon the vacant state land.

According to a report published by the Chamber of Commerce of Essen for last year, the number of employees or workmen in the Krupp establishment is no less than 64,354, which is an increase of 2,000 over last year. The workmen are installed in 4,691 model dwellings belonging to the company, and a number of establishments are now designed for the use of employees, to wit, a hospital, two lazarets for contagious diseases, a sanatorium for convalescents (to this will be added two others during the present year), a medical bath establishment, three hospices, a workmen's building containing 1,170 lodgings and having kitchens arranged so as to feed 3,000 persons per day, six restaurants, two furnished hotels for about thirty unmarried technical employees, housework schools and others designed for technical industry for the use of adults, a large library, reading rooms, savings bank, dental hospital and other institutions. The Krupp firm paid out during the last year in insurance premiums for age, accidents, etc., to its employees, sums which aggregate over $2,000,000.

Owing to the great success which is now obtained by the Simplon Tunnel, it has been decided to proceed with the execution of the original project, which calls for a double tunnel. In fact at the time of the present construction, arrangements were made so that the [illegible] ould be executed without trouble at a later period. The time has now come, and somewhat sooner than was expected, when the railroad can make use of the second tunnel to advantage, and the council of administration of the federal railroad department came to a decision not long since in favor of running the new tunnel. This work will require some time to carry out, but it will not have the unusual difficulties which were met with upon the first tunnel from the great water flow, leading to a great delay and much work in conveying off the water. This has now been accomplished in a great measure, and no further drawback is expected in this direction. According to the present plans, the second tunnel will have a somewhat larger section than the first, and it will have a greater number of side recesses along its course. Instead of lime coating for the inside of the tunnel, Portland cement will be used. In order to carry off the water from the hot springs it will be necessary to afford two drains of large section, running along each side of the tunnel. The drains will lead to the opening on the Italian side of the tunnel. The general plans for the construction of the new tunnel have now been drawn up by the engineers, and were approved by the administration.

TRADE NOTES AND FORMULÆ.

Yellow Stain for Ivory.—(*a*) 60 parts of finely ground curcuma root, digested in 500 parts of 80 per cent alcohol for a day and filtered through blotting paper. (*b*) 95 parts of aniline yellow dissolved in 7[illegible] parts of 80 per cent alcohol and filtered through blotting paper.

Silver Polish for Articles of Ivory.—The pieces must be placed in a weak solution of nitrate of silver until they have assumed a dark yellow color. Then transfer them to clear water and expose them to direct sunlight. After 3 hours they will be black; when rubbed with a leather they become silvery bright.

Black Stain for Ivory.—1 part finely-crushed gall nuts, 4 parts pulverized verdigris boiled in 30 parts, by weight, of water, the fluid to be strained and again brought to boiling. The ivory to be immersed in it and afterward placed in the following bath: 1 part Campeachy wood extract (tied in a linen bag), [illegible] part acetate of iron, 0.1 part gum Arabic, 12 parts water, 1/12 part alum, boiled for 1 hour and strained.

Violet Stain for Ivory.—(*a*) First place the ivory in water for a few minutes with some muriate of tin solution, then in a decoction of 5 parts of Campeachy wood and 30 parts water for one hour. (*b*) 500 parts of Brazil wood chips boiled in 1,250 parts of water for 1 hour, filtered, and to this added a solution of 120 parts of green vitriol in 250 parts of water. (*c*) 300 parts of alcohol and 30 parts of aniline violet, filtered.

Red Stain for Ivory.—(*a*) Boil Brazil wood chips in weak alum water and filter. The ivory should be previously treated with dilute muriate of tin solution. (*b*) 2 parts of alum dissolved in 25 parts of water, then the ivory is treated with Brazil wood decoction. (*c*) Solution of 4 parts cochineal, 4 parts cream of tartar, 12 parts tin solution (finely powdered cochineal to be dissolved in warm tin solution and cream of tartar added). After solution is effected spirit of sal ammoniac is added drop by drop.

Strawberry Vinegar.—This is a fruit product that is too little known and esteemed, adapted for use in the preparation of refreshing beverages and for the flavoring of various sauces. Well ripened dry strawberries are placed in wide-mouthed glass bottles or stone jars and to each 250 parts of fruit by weight 1,000 parts of the best white wine vinegar is added. The vessels are allowed to stand, carefully closed, for 3 days, then the vinegar is poured off and again poured over 500 parts of strawberries, allowed to draw for 3 days, after which the pouring over fresh fruit is repeated for the third time. The vinegar by this time thoroughly saturated with the aroma of the strawberries is filtered through a linen cloth, and in a new, well-glazed casserole, boiled over a quick fire for about 5 minutes and carefully skimmed. After cooling, it is drawn into bottles, tightly corked and kept in the cellar until needed.

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